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UNITED STATES AIR FORCE

GRADUATE STUDENT RESEARCH PROGRAM

1990

PROGRAM TECHNICAL REPORT

UNIVERSAL ENERGY SYSTEMS, INC.

VOLUME 3 OF 3

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SUBMITTED TO

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The Summer Faculty Research Program (SFRP) was initiated in 1982. The Graduate Student Research Program (GSRP) is an adjunct effort to the Summer Faculty Research Program. Its purpose is to provide opportunities for selected graduate students to perform summer research at Air Force laboratories with supervising professors who hold concurrent SFRP appointments or with Air Force researchers.

The program is available to graduate students enrolled in either Masters Degree or Doctorate Programs. It has proven especially beneficial to the students who are starting their academic research programs.

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Submitted to

Air Force Office of Scientific Research

Bolling Air Force Base

Washington, DC

December 1990

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PREFACE

The United States Air Force Graduate Student Resarch Program (USAF-GSRP) is conducted under the United Air Force Summer Faculty Research Program. ~~The program~~ provides funds for selected graduate students to work at an appropriate Air Force facility with a supervising professor who holds a concurrent Summer Faculty Research Program appointment or with a supervising Air Force Engineer/Scientist. This is accomplished by the students being selected on a nationally advertised competitive basis for a ten-week assignment during the summer intersession period to perfrom research at Air Force laboratories/centers. Each assignment is in a subject area and at an Air Force facility mutually agreed upon by the students and the Air Force. In addition to compensation, travel and cost of living allowances are also paid. The USAF-GSRP is sponsored by the Air Force Office of Scientific Research, Air Force Systems Command, United States Air Force, and is conducted by Universal Energy Systems, Inc.

The specific objectives of the 1990 USAF-GSRP are:

(1) To provide a productive means for the graduate students to participate in research at Air Force Laboratories/Centers;

(2) To stimulate continuing professional association among the graduate students and their professional peers in the Air Force;

(3) To further the research objectives of the United States Air Force;

(4) To enhance the research productivity and capabilities of the graduate students especially as these relate to Air Force technical interests.

During the summer of 1990, 121-graduate students participated. These researchers were assigned to 23 USAF laboratories/centers across the country. This three volume document is a compilation of the final reports written by the assigned students members about their summer research efforts.

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RESEARCH REPORTS

This report includes the following

RESEARCH REPORTS

1990 GRADUATE STUDENT RESEARCH PROGRAM

Technical Report Number	Title	Graduate Researcher
Volume I		
Armament Laboratory		
1	Two-Dimensional Simulation of Railgun Plasma Armatures *** Same Report as Dr. Manuel Huerta ***	George Boynton
2	Infrared Laser Polarimetry	Randy Gove
3	Computing Circumcenters	Leonard Issacs
4	High Speed Video Systems for Munitions Testing	Davis Lange
5	Physical Aspects of the Penetration of Reinforced Concrete Slabs *** Same Report as Dr. Eugene Carden ***	Christopher Wanstall
Arnold Engineering Development Center		
6	High-Speed Parallel Signal Processing	Ben Abbott
7	High Speed Parallel Signal Processing *** Same Report as Ben Abbott ***	Theodore Bapty
8	Graphics for Turbine Math Models	Ronald Blume
9	s90 Graphing System	Jordan Cahn
10	A Neural Network for the Analysis of Test Data from the Aeropropulsion Systems Test Facility	James Golden
11	AI Applications for Gas Turbine Engine Testing	Dollena Hawkins
12	Investigations of Acoustic Resonance Phenomena Using Computer Animation Postprocessing	Everett King
13	Exhaust Plume Prediction Method for Underexpanded Nozzles in Supersonic External Flows	Kyle Nash

Volume I

Volume I
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Volume I

Volume II

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FINAL REPORT

Simulation of Head/Neck Response to -Gx Impact Acceleration

Prepared by:	Amit Lal Patra, Ph.D.
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Date:	August 10, 1990
Contract No:	F49620-88-C-0053

Same Report as
Prof. Amit Patra
(Report # 127)

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FINAL REPORT

GESTATIONAL AND LACTATIONAL TRANSFER OF HEXACHLOROBENZENE FROM THE MATERNAL RAT DOSED PRIOR TO BREEDING

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Date:	30 Sep 90
Contract No:	F49620-88-C-0053

GESTATIONAL AND LACTATIONAL TRANSFER OF HEXACHLOROBENZENE FROM THE MATERNAL RAT DOSED PRIOR TO BREEDING

by

Ellen S. Goldey

ABSTRACT

The maternal transfer of hexachlorobenzene (HCB) to fetuses and suckling pups was assessed using a prebreeding dosing design. Two weeks prior to breeding, virgin Sprague-Dawley rats were given a total oral dose of HCB in corn oil of 10 or 100 mg/kg body weight over four days. Concentrations of HCB were determined in the tissues of at least 3 dams and their offspring for each of days 9, 15 and 21 of gestation and on postnatal (PN) days 4, 7, 10, and 14. In all reproductive states of the dam, the fat had the highest concentration of HCB. During pregnancy, maternal blood HCB concentrations were low relative to the other tissues, which suggests that HCB was in relatively stable equilibrium between the blood and tissue storage compartments at this time. Hexachlorobenzene was detected in early, mid and late gestation fetuses suggesting that HCB may begin exerting toxic effects early in development. The maternal body burden of HCB was quickly depleted by lactational transfer of the HCB to the suckling pups as reflected in high HCB concentrations in the milk. The relative concentration of HCB in the pups rapidly exceeded the levels in the dams during lactation, and high levels remained in pup tissues at the termination of the experiment. Throughout gestation, the HCB tissue concentrations between the 10 and 100 mg HCB/kg body weight groups differed by a factor of 10 as expected. However, soon after the onset of lactation, there was only a 1-3 fold difference in tissue concentration between the two groups. This suggests that different rates and/or routes of elimination are invoked for different initial body burdens of the compound.

ACKNOWLEDGMENTS

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Special thanks goes to the men and women of the Toxic Hazards division of the AAMRL. Especially, I would like to thank Dr. Jeffrey Fisher for his help on this project. His advice and guidance were invaluable. Thanks also to Krista Meyer, Jennifer Renkins, and Andrea Lengel for their help with sample preparation.

I. INTRODUCTION

Organochlorine pollutants represent a widespread health threat to humans. Many polyhalogenated compounds are metabolized slowly and are lipophilic, and lifetime exposure to low levels of these contaminants may lead to relatively high concentrations in the adipose tissue. Numerous chlorinated compounds, including hexachlorobenzene (HCB), polychlorinated biphenyls, and chlorinated dibenzofurans and dioxins are commonly detected in the adipose tissue of humans (US EPA, 1985). While these compounds are sequestered in the fat, the health risk to the human adult may be minor. The risk to both the fetus and the suckling offspring, however, may be high when the chemical is mobilized from the fat due to the change in metabolic state of the mother during pregnancy, and/or in the excretion of the chemical with the milk during lactation due to the breakdown of adipose for milk fat production. Developing organisms are generally more sensitive to the effects of toxins than adults, therefore it is imperative that testing procedures be used that assess the risk of these chemicals on the human fetus and suckling infant.

Hexachlorobenzene, (HCB) a chlorinated hydrocarbon, has been detected in nearly 100% of human adipose tissue samples tested (Mack and Mohadjer, 1985). The major route for human exposure to HCB is ingestion and absorption from the gastrointestinal tract (Matthews, 1986). Metabolism is very slow and the primary excretory route is in the faeces (Matthews, 1986). Studies have demonstrated that HCB crosses the placenta where it may affect the developing fetus (Courtney and Andrews, 1979), and it is also present at relatively high concentrations in human milk in some parts of the world (Weisenberg, 1986).

Using the rat as an animal model, and hexachlorobenzene as a model compound, I developed and utilized a protocol for an assessment of the maternal transfer of HCB, from a relatively stable maternal body burden of the chemical to the fetuses and pups.

Protocols currently used to determine the teratogenic effects of a compound require repeated dosing of the maternal animal with the chemical throughout gestation and lactation. These types of protocols best mimic human accidental exposure to large doses a chemical that may be quickly metabolized and/or excreted from the body. I believe that it does not mimic the transfer of chemicals that have accumulated slowly to a relatively stable level in the body. In addition repeated dosing of the animal increases the likelihood that teratogenic effects seen in the offspring reflect maternal toxicity due to such factors as handling stress (Chernoff et al., 1989) rather than effects of the chemical. Therefore a different protocol may be required in order to determine the teratogenicity of metabolically stable compounds such as HCB.

I developed and utilized an animal model protocol that could be consistently used for risk assessments of the effects of metabolically stable, lipophilic compounds on the developing offspring. A primary concern was to establish a protocol that would allow an assessment of the transfer of HCB from relatively stable stores of the chemical in the body of the dam to the fetus and, subsequently to the suckling offspring. My procedure also greatly reduces handling of the animals and therefore reduces maternal toxicity to the developing offspring and it is more cost/time effective for the researcher. I believe that the results obtained from this procedure demonstrate the potential for widespread use of this protocol for teratogenicity assessments with other organochlorine compounds.

The current project is relevant to the Installation Restoration Program. This research program is aimed at solving risk assessment problems associated with clean-up of landfills on Air Force bases. Hexachlorobenzene is a common long-lived contaminant in the environment as well as in the body. Consequently, exposure is widespread and the bioaccumulation of this compound may represent a health risk. The Toxic Hazards Division (THA) of the Armstrong Aerospace Medical Research Laboratory is interested in toxicokinetics as it relates to pregnant women and those with breast-feeding infants. Currently emphasized in this division is the development of pharmacokinetic models to be

used in risk assessments for women who are potentially exposed to xenobiotics in the workplace and through bioaccumulation from the environment. The extensive database that I have generated will be useful for the development of a pharmacokinetic model for the gestational and lactational transfer of hexachlorobenzene.

My research indicates that prebreeding dosing results in relatively stable body burdens of the chemical during pregnancy, and that the chemical is transferred to the pups throughout lactation through the dams milk in a predictable fashion. I feel that pharmacokinetic models developed for lipophilic, metabolically stable chemicals such as hexachlorobenzene, PCBs and other halogenated compounds will be more accurate if a prebreeding dosing protocol rather than a continuous dosing procedure is used.

I have extensive experience with gas chromatographic analysis of chemical residues in tissues. My current research involves not only the characterization of the tissue kinetics of HCB, but also the developmental toxicity and behavioral teratology of this compound. This experience contributed to my assignment to the Toxic Hazard Assessment branch of the AAMRL for the current project.

II. OBJECTIVES OF THE RESEARCH EFFORT

a. To evaluate the tissue kinetics of HCB during pregnancy and lactation, and to compile a complete database useful for the development of a pharmacokinetic model of HCB during pregnancy and lactation. A tissue dosimetry study provides partition coefficient information and a clear indication of major target compartments to be used in the development of the model. In general, comparison of the kinetics of a compound at two different dosage levels is rarely performed, however the current study indicates that such a comparison is important in order to assess whether the differing initial body burdens of the compound have similar transfer kinetics.

b. To develop a dosing procedure that would be widely applicable to researchers assessing the teratogenicity of metabolically stable, polyhalogenated compounds. The protocol provides an environmentally realistic approach to this type of study by allowing the compound to equilibrate within the tissues prior to altering the reproductive state of the animal. It also reduces the actual handling time of the animals by the researcher.

c. To remove blood-borne HCB by perfusion with saline from a representative sample of animals. In this way one could determine how much of the chemical is actually in the tissue of a particular organ, and compare it to how much of the chemical is contained within the circulatory vessels perfusing that organ.

d. To determine the oral uptake of HCB from the gastrointestinal tract to the blood stream by collecting blood samples at regular time intervals following dosing.

e. To determine HCB concentrations in target organs that are under further study in our laboratory. We are currently assessing the neuroteratology of HCB through histological analysis of the brain and the evaluation of maternally exposed pups in a behavioral test battery. The existence of numerous anecdotal reports of behavioral anomalies in humans exposed to HCB advocates the importance of an indepth neurological analysis such as ours. Detection of HCB in the brains of developing rats supports the possibility that the central nervous system is a target site for HCB toxicity. Histological methods are also being used to assess the developmental effects of HCB other target tissues, particularly the kidney.

III. METHODS

a. Hexachlorobenzene was dissolved in corn oil, and total dosage of 10 or 100 mg/kg was administered to virgin Sprague-Dawley rats over 4 days by gavage two weeks prior to breeding. This allowed the body burden of HCB to compartmentalize and to stabilize in the rats' tissues. Rats were weighed twice weekly, and food and water were available *ad lib.* Rats were pair bred in suspended cages, and the day a sperm plug was located on the paper under the cage was designated as day zero of gestation. Litters were culled to eight pups at birth.

b. Groups of 3 or 4 rats and their offspring were sacrificed at designated stages of gestation to determine maternal concentrations of HCB in the blood, perirenal fat, brain, liver and kidney. Whole fetuses were collected for analysis on gestation day 9, fetuses, amniotic fluid and placentas fluid were collected on gestation day 15 and on gestation day 20, whole fetuses, amniotic fluid, placentas, fetal blood, livers and brains were collected for HCB analysis. Additionally, maternal and pup tissues were collected 4, 7, 10 and 14 days post partum to assess the lactational transfer of the compound. Dam blood, liver, kidney, brain, fat and milk and pup blood, liver, kidney and brain were collected at these time points. Additionally, four pups per litter were anesthetized and perfused with saline to remove blood-borne HCB from the tissues.

c. Hexachlorobenzene was extracted from the tissues by homogenizing the tissue in 10 vol. of hexane, centrifuging the homogenate and assaying each sample in duplicate by direct injection onto a Hewlett Packard (5890 series) gas chromatograph equipped with an ^{63}Ni electron capture detector.

d. Additionally, two groups of 6 female rats were dosed with HCB as described above (2.5 or 25 mg HCB/kg body weight/day for 4 days). The oral uptake of HCB was determined from blood samples collected at regular intervals over the 4 day dosing period. On the first day blood was collected at 30 min, 1 h, 2 h, 3 h, 4 h and 24 h intervals following dosing. The 24 h sample was collected immediately prior to the administration of the next day's dose. On the second, third and fourth day of dosing, blood was collected at 1 h, 4 h, and 24 h intervals. Blood was collected from the tail vein of each rat after immobilizing the animal in a plastic restraint cylinder. A heparinized microhematocrit capillary tube was fitted into the base of a 25-gauge disposable needle, and the needle was inserted into the lateral vein of the tail. Blood filled the tube by capillary action (70 ul). Samples were taken from distal to proximal locations along the length of the tail. Blood samples were placed directly into hexane, centrifuged and the hexane layer analyzed for HCB concentration as described above.

IV. RESULTS

a. The concentration of HCB in maternal tissues declined gradually throughout gestation (Table 1 and 2). The HCB levels in blood were low compared to the other tissues, which suggests that the compound is in dynamic equilibrium among the tissue storage compartments. The adipose tissue is the largest sink of HCB, although HCB is also stored in the other tissues preferentially to being carried in the circulation. It is of interest to note the expected 10 fold difference between the 10 and 100 mg/kg dosage groups for all tissues.

I detected HCB in fetal tissues from our earliest sample date (day 9 of gestation) and throughout gestation (Table 3 and 4). In general, the HCB concentration in placental tissue reflects the maternal blood concentration of HCB (see Tables 1 and 2 for dams). As would be expected for a lipophilic compound, the amount of HCB in amniotic fluid was low: it

Table 1: Hexachlorobenzene concentration (ng/g) ± S.E. in maternal tissues throughout gestation for animals exposed to a total dose of 10 mg HCB/kg body weight two weeks prior to breeding. Values in parentheses indicate number of dams included in each sample at 9, 15 or 20 days post conception.

		Tissue Type				
Day of gestation	(N)	Blood	Liver	Kidney	Brain	Fat
9	(3)	335.60 ± 18.77	1304.33 ± 38.13	1088.39 ± 229.5	1199.04 ± 201.9	49946.62 ± 1060
15	(3)	303.51 ± 7.31	1051.22 ± 47.05	734.58 ± 54.37	964.49 ± 53.77	49175.82 ± 1214
20	(3)	285.11 ± 12.07	855.18 ± 60.33	712.31 ± 95.09	685.49 ± 60.97	35271.03 ± 1175

Table 2: Hexachlorobenzene concentration (ng/g) ± S.E. in maternal tissues throughout gestation for animals exposed to a total dose of 100 mg HCB/kg body weight two weeks prior to breeding. Values in parentheses indicate number of dams included in each sample at 9, 15 or 20 days post conception.

		Tissue Type				
Day of gestation	(N)	Blood	Liver	Kidney	Brain	Fat
9	(2)	2229.33 ± 838.78	13181.17 ± 342.29	7310.00 ± 1002	9238.58 ± 714.8	397059.5 ± 13297
15	(3)	3211.37 ± 218.11	11179.61 ± 641.48	8352.75 ± 760.8	12272.46 ± 1251	346359.2 ± 11668
20	(3)	2837.19 ± 369.4	8569.72 ± 991.9	6128.88 ± 858.2	7141.09 ± 636.9	305884.3 ± 50248

Table 3: Hexachlorobenzene concentration (ng/g) ± S.E. in tissues collected from fetuses whose dams were exposed to a total dose of 10 mg HCB/kg body weight two weeks prior to breeding. Tissues may have been pooled for fetuses within a litter.

Day of gestation	(N)	Whole fetus	Placenta	Amniotic fluid	Blood	Liver	Brain
		Tissue Type					
9	(3)	156.98 ± 56.91	NA[a]	NA	NA	NA	NA
15	(3)	192.54 ± 20.51	252.41 ± 11.58	ND[b]	NA	NA	NA
20	(3)	282.64 ± 8.63	305.64 ± 14.64	ND	255.38 ± 24.11	270.25 ± 21.73	163.08 ± 21.04

[a] NA indicates that the tissue was not collected for analysis.
[b] ND indicates that the concentration of HCB was below the level of detection.

Table 4: Hexachlorobenzene concentration (ng/g) ± S.E. in tissues collected from fetuses whose dams were exposed to a total dose of 100 mg HCB/kg body weight two weeks prior to breeding. Tissues may have been pooled for fetuses within a litter.

Day of gestation	(N)	Whole fetus	Placenta	Amniotic fluid	Blood	Liver	Brain
		Tissue Type					
9	(3)	1071.96 ± 153.8	NA[a]	NA	NA	NA	NA
15	(3)	1998.605 ± 119.0	3395.52 ± 695.9	340.26 ± 51.90	NA	NA	NA
20	(3)	2085.90 ± 222.5	3158.50 ± 486.1	179.34 ± 24.00	2402.97 ± 512.8	2356.25 ± 180	1370.99 ± 161.2

[a] NA indicates that the tissue was not collected for analysis.

was below the level of detection in samples collected from the 10 mg/kg group. Since we are particularly interested in the developmental neurotoxicity and nephrotoxicity of HCB, the presence of HCB in the brain and kidneys of fetuses suggests that the onset of toxicity to these organs may begin during pregnancy.

The maternal body burden of HCB is rapidly depleted during lactation (Table 5 and 6). An important finding was that the expected 10 fold difference between the two treatment groups disappeared after the onset of lactation. Table 7 compares a concentration factor, RCF (the HCB concentration in a particular tissue from animals dosed with 100 mg HCB/kg body weight divided by the HCB concentration in the same tissue from animals exposed to 10 mg HCB/kg body weight) for all tissues analyzed. The RCF for dam tissues during gestation ranged from 6.64 to 12.72 with a mean RCF of 9.32, whereas the RCF for dam tissues during lactation ranged from 1.04-4.71 with a mean value of 2.77. The difference between gestation RCFs and lactation RCFs suggests that the rate and/or route of elimination differs between the treatment groups after the onset of lactation. A seemingly likely explanation is that the change is due to a relatively more rapid release of the the chemical during the first 4 days of lactation in the higher dosage group. However, if the HCB was simply dumped to the pups within the first few days of lactation, one would expect the HCB to still be in the body of the pups on postnatal day 4. The mean RCF calculated from HCB concentrations in pup tissues (Table 8 and 9) was 2.61 which suggests that the phenomenon is more complex, and it would be of interest to conduct further study to determine the mechanism of this phenomenon.

b. There was little difference between the HCB concentration in tissues collected from animals perfused with saline and those that were not perfused which suggests that blood circulating through the organ may contribute very little HCB to overall tissue levels. The bulk transfer phenomenon is clearly depicted in the rapid increase of HCB tissue concentration in the suckling pups (Table 3).

Table 5: Hexachlorobenzene concentration (ng/g) ± S.E. in maternal tissues throughout lactation for animals exposed to a total dose of 10 mg HCB/kg body weight two weeks prior to breeding. Values in parentheses indicate the number of dams included in the sample at 4, 7, 10, and 14 days postpartum.

		Tissue Type					
Day of lactation	(N)	Blood	Liver	Kidney	Brain	Fat	Milk
4	(3)	1201.53 ±169.9	1863.56 ± 331.5	1016.58 ± 193.05	1304.03 ± 28.29	82119.84 ± 12115	3561.56 ± 2024
7	(3)	513.55 ± 57.92	562.89 ± 158.6	421.56 ± 124.1	453.38 ± 94.95	26500.69 ± 6221	1703.59 ± 373.1
10	(3)	227.90 ± 122.0	252.46 ± 240.8	120.89 ± 111.0	148.01 ± 135.7	14773.02 ± 11138	504.83 ± 307.1
14	(3)	41.67 ± 11.82	15.98 ± 5.37	19.24 ± 6.47	24.92 ± 8.33	2185.18 ± 880.9	61.97 ± 12.55

Table 6: Hexachlorobenzene concentration (ng/g) ± S.E. in maternal tissues throughout lactation for animals exposed to a total dose of 100 mg HCB/kg *body weight two weeks prior to breeding. Values in parentheses indicate the number of dams included in the sample at 4, 7, 10, and 14 days* postpartum.

		Tissue Type					
Day of lactation	(N)	Blood	Liver	Kidney	Brain	Fat	Milk
4	(3)	1375.41 ± 299.6	6404.73 ± 139.2	3066.71 ± 356.4	4389.44 ± 380.2	223799.2 ± 17515	3717.59 ± 1200
7	(4)	1228.82 ± 300.5	1964.75 ± 482.8	1070.13 ± 306.8	1360.42 ± 254.6	88067.97 ± 16301	1944.38 ± 390.5
10	(4)	460.95 ± 89.49	979.58 ± 134.7	502.42 ± 98.85	760.77 ± 111.6	49431.98 ± 7102	1035.50 ± 350.2
14	(3)	123.02 ± 87.83	142.55 ± 90.68	101.79 ± 49.41	130.93 ± 76.88	8837.25 ± 6111	92.76 ± 68.83

Table 7: The relative concentration factor, RCF = [tissue] $_{100}$ ÷ [tissue] $_{10}$, for dam, fetus and nonperfused pup tissues.

Dam tissues

	Brain	Kidney	Liver	Fat	Blood	Milk
Gestation 9	7.71	6.72	10.11	7.95	6.64	
Gestation 15	12.72	11.37	10.63	7.04	10.58	
Gestation 20	10.42	8.60	10.62	8.67	9.95	
Lactation 4	3.37	3.02	3.44	2.73	1.15	1.04
Lactation 7	3.00	2.54	3.49	3.32	2.39	1.14
Lactation 10	4.71	3.70	3.55	3.21	2.02	2.05

Fetal tissues

	Whole fetus	Placenta	Blood	Liver	Brain
Gestation 9	6.82	NA	NA	NA	NA
Gestation 15	10.38	13.45	NA	NA	NA
Gestation 20	7.38	10.33	9.41	8.72	8.41

Pup tissues (nonperfused)

	Brain	Kidney	Liver	Blood
Post natal 4	5.61	3.21	3.18	2.31
Post natal 7	2.40	2.49	3.25	2.07
Post natal 10	2.54	2.33	2.38	1.95
Post natal 14	1.85	2.64	1.84	1.85

Table 8: Hexachlorobenzene concentration (ng/g) ± S.E. in pup tissues collected 4, 7, 10 and 14 days postpartum. The dams of these animals were exposed to a total dose of 10 mg HCB/kg body weight two weeks prior to breeding. Four pups from each litter were perfused with saline to remove blood-borne HCB from the tissues. Perfused tissues were analysed separately from non perfused tissues. The value in parentheses indicates the number of litters analysed for each age group. Tissues may have been pooled from pups within a litter.

Day (N)	Tissue Type			
Not perfused	Blood	Liver	Kidney	Brain
4 (3)	4097.64 ± 495.3	6213.42 ± 1239	2312.83 ± 255.5	1115.89 ± 194.1
7 (3)	4615.46 ± 280.0	5609.26 ± 452.2	2381.28 ± 316.8	1394.34 ± 114.9
10 (3)	4920.59 ± 686.1	4325.22 ± 719.7	2584.51 ± 298.9	1806.21 ± 260.8
14 (3)	3066.03 ± 378.6	3189.40 ± 309.6	1779.18 ± 330.1	1288.67 ± 144.9
Perfused				
4 (3)	NA[a]	6979.46 ± 2193	2520.44 ± 735.1	1132.33 ± 191.9
7 (3)	NA	4545.49 ± 562.6	2300.60 ± 216.8	1379.77 ± 121.8
10 (3)	NA	4111.73 ± 490.5	3005.68 ± 823.9	1539.04 ± 88.07
14 (3)	NA	3006.80 ± 386.6	1930.88 ± 253.0	1437.40 ± 318.4

[a] NA indicates that no blood was collected from these animals.

Table 9: Hexachlorobenzene concentration (ng/g) ± S.E. in pup tissues collected 4, 7, 10 and 14 days postpartum. The dams of these animals were exposed to a total dose of 100 mg HCB/kg body weight two weeks prior to breeding. Four pups from each litter were perfused with saline to remove blood-borne HCB from the tissues. Perfused tissues were analysed separately from non perfused tissues. Numbers in parentheses indicate number of litters analysed. Tissues may have been pooled from pups within a litter.

Day (N)	Tissue Type			
Not perfused	Blood	Liver	Kidney	Brain
4 (3)	9487.35 ± 2395	20971.44 ± 738.2	8408.36 ± 1132	6182.85 ± 485.2
7 (3)	9581.09 ± 1154	14051.06 ± 1577	5429.55 ± 684.61	3583.20 ± 351.6
10 (4)	9583.43 ± 3143	10313.41 ± 2055	6009.90 ± 911.0	4591.41 ± 1109
14 (3)	5671.97 ± 2019	5876.83 ± 760.5	4691.12 ± 673.13	2483.13 ± 311.8
Perfused				
4 (3)	NA[a]	16568.01 ± 1120	8661.98 ± 563.7	8283.82 ± 641.9
7 (3)	NA	13136.71 ± 2364	6100.29 ± 1132	3866.11 ± 704.1
10 (4)	NA	8728.14 ± 1131	5833.42 ± 905.0	3844.74 ± 716.8
14 (3)	NA	5247.48 ± 498.0	3124.34 ± 574.7	2988.51 ± 476.2

[a] NA indicates that no blood was collected from these animals.

c. The oral uptake study indicated that uptake from the intestine to the blood most likely occurs within four hours. The blood HCB concentration appears to be relatively stable over the intervening hours until the next dose is given which suggests that it may take several days for HCB to move from the bloodstream to tissue storage compartments (Figures 1 and 2).

V. RECOMMENDATIONS

a. The results of this study should be used in the development of a physiologically based mathematical model for the maternal transfer of HCB. This model will useful in the establishment of risk assessment guidelines for HCB and other xenobiotics of similar structure and activity.

b. We have demonstrated that HCB is present in fetuses throughout gestation and is transferred in bulk to the pups during lactation. Dams efficiently clear their body burden of HCB during lactation, and by postnatal day 14, levels are below the level of detection for most tissues from the 10 mg HCB/kg body weight group. Levels in the pups, however, were high, and HCB presumably remains in constant flux in the body since there is no fat storage compartment in young pups. This suggests that pups are exposed to HCB throughout development. Since the HCB is present in the brain of these animals, and the development of many structures within the brain are not complete until approximately 28 days of age, the brain is a likely target for the teratogenic effects of HCB. Work currently progressing in our laboratory indicates that this is indeed the case.

c. Although the more traditional assessments of teratological effects of HCB, such as an assessment of liver porphyria, were beyond the scope of the present study, we believe that the pre-breeding dosing strategy used here is a realistic approach for assessing the

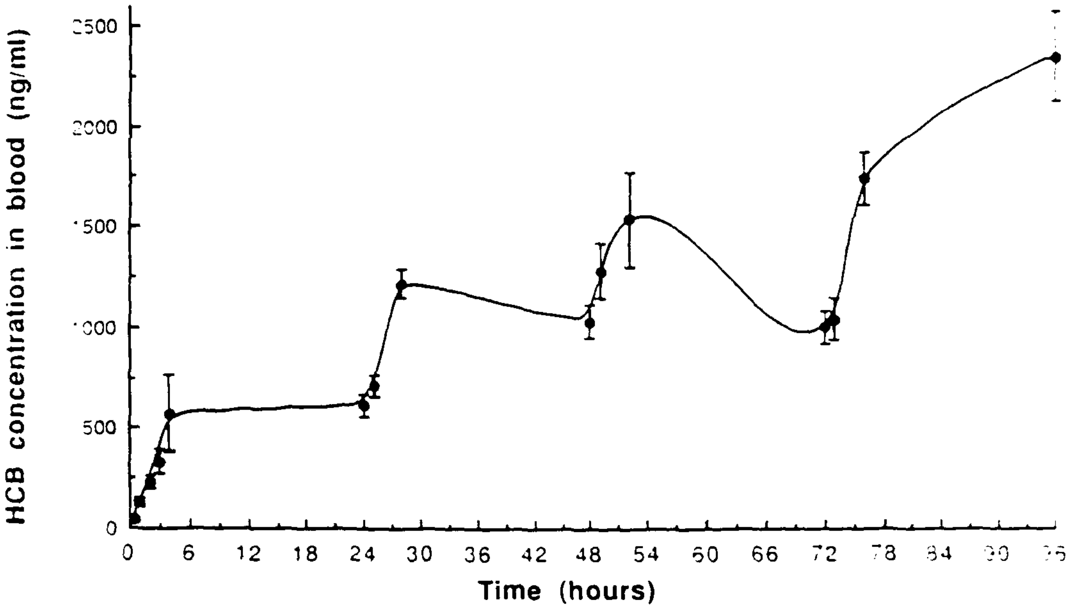

Figure 1. Blood concentration of HCB (±S.E.) after gavage dose of 2.5 mg/kg per day for 4 days. Total dose = 10 mg/kg.

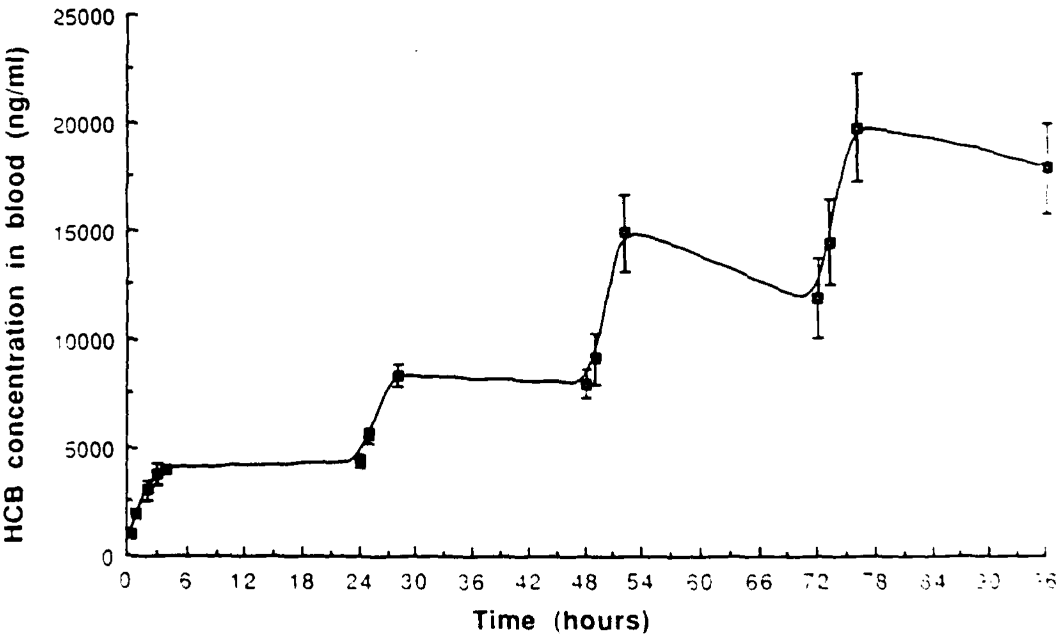

Figure 2. Blood concentration of HCB (±S.E.) after gavage dose of 25 mg/kg per day for 4 days. Total dose = 100 mg/kg.

developmental toxicity of organochlorine pollutants in general. Regulatory agencies such as the EPA are seeking more realistic protocols for teratological assessments. Existing protocols in which maternal rats are dosed with the chemical repeatedly throughout gestation and lactation are environmentally unrealistic situations. Humans are exposed to chemicals that are present in low levels in the environment and bioaccumulate in the body throughout one's lifetime. The protocol used in the present study provides sufficient time prior to breeding to allow for the stabilization of the chemical in the maternal rat. Recent findings also demonstrate the importance of reducing the effects of maternal stress on the developing animal (Chernoff et al., 1989). My protocol reduced maternal stress via less invasive handling of the animals and it also allows the researcher time to evaluate the overall health of the animal prior to the onset of pregnancy. Thus it may be possible to make a more objective judgement as to whether maternal toxicity may have played a role in the final outcome.

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1990 USAF-UES SUMMER FACULTY RESEARCH PROGRAM/

GRADUATE STUDENT RESEARCH PROGRAM

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FINAL REPORT

DECISION-MAKING UNDER SYSTEM FAILURE CONDITIONS

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Date:	27 August 90
Contract No.:	F49620-88-C-0053

Same Report as
Prof. Bonnie Walker
(Report # 129)

1990 GRADUATE STUDENT RESEARCH PROGRAM

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Universal Energy Systems, Inc.

FINAL REPORT

STATISTICAL ANALYSIS OF CIVIL DISORDERS:1964-1989

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Date:	8 Aug 90
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This 10-week program really helps me to apply the statistical techniques of Poisson process and Markov chain into my social study. My sincere thanks goes to Dr. Robert Carpenter who lends me his own personal computer by which I can run BMDP subroutine regression line and type my final report. The help of HM3 Von Rix was invaluable in overcoming many technical roadblocks.

1. INTRODUCTION

In the era of 1960s, America experience lots of civil disorders. Civil disorders is a form of riot. In the branch of collective behavior, riot is a very prominent phenomenon with its destructive power. The central factors were the existence of separate social worlds; the behavior of the police; the feelings of frustration and the inability of minority groups to bring about political and economic change. Clearly, a high percentage of unemployment, poor housing, crowded living conditions, hopelessness made the ghetto residents angry and bitter. What make their lives even unbearable was the facts that they would never reach the affluent lives which were enjoyed by the majority of the whites (Boskin,1969).

Because of its highly visibility of social disturbance, a report of the National Advisory Commission on Civil Disorder were written under the leadership of Governor, Otto Kerner in 1968. It is the so called Kerner Report.

The Lemberg Center of Brandeis University also did some research on the topic of civil disorders. I got some ideas from them to do some descriptive analysis.

Spilerman of Madison, Wisconsin has done some research on civil disorder by applying the Poisson Process. The major difference between Spilerman's and my approach is that he is using spatial point process while I am using the temporal one. Spilerman used city as unit of analysis. Because of the heterogeneity among the cities, Spilerman concludes that a homogeneous Poisson Process is not appropriate for modeling the occurrence of riot. The unit of analysis in my paper is day. It is found that the homogeneous Poisson Process is suitable for modeling the occurrence of riot. I am going to review the properties of Poisson Process later on to facilitate my discussion.

2. DESCRIPTIVE ANALYSIS

2.1 The Data

This paper is focusing on civil disorder itself during the past 25 years from 1964-1989. The questions posed in this paper are: Is riot really intensified during the 60s? What happens after the 60s? Is riot randomly distributed? What is the rate of occurrence of riot for each year? Also, it is attempted to build a two-state Markov chain to model the event of riot.

The primary source of data for this report is New York Times Index. The accounts are obtained by collecting the riot news from the Black section. The use of this journalistic accounts has several shortcomings. First, we are uncertain of the accuracy or reliability of specific information contained in press report. The journalistic account of civil disorders tend to provide information on the very large and extreme violent outbursts than on lesser events. Thus we are less confident in the completeness of our information on small events. For example, we can only collect certain days of extremely violent outburst of Watts Riots in 1965. Actually, according to the book, "Introduction to Collective Behavior" (Miller, 1985), Watts Riots should be started on August 11. It's one day earlier than the date I collect from the New York Times Index. Also, there are report of hundred occurrence of riots in Washington, DC alone in 1968 when Martin Luthur King, Jr. was assassinated, but the total accounts of riots I can get from the New York Times Index are only 63 times. For the above reason, our data utilized in the paper should be treated as providing approximate rather than absolute measure. Second, we only use one single national level source in this paper -- New York Times Index rather than the multi-level sources. Thus, it is almost impossible for us to get detailed information on the sequence of events during riots merely

from newspaper. Even though our data is not very complete, it is highly compatible with the one collected by the Lemburg Center of Brandeis University. Please see Section 2.4 for a comparison between Fig. 1a and 1b.

Similar to the study by the Lemburg Center of Brandeis University, we also define civil disorders as events involving crowd behavior, characterized by either damage to persons or property, or aggressive disruptions which violate the civil law. Race-related civil disorders are identified as norm-violating events characterized by violent behavior by members of one racial or ethnic group against members of another racial group. Such behavior is characterized by the following factors: (1) group members: identification of the participants with their racial group is salient. (2) motivation: individuals become involved in an aggressive incident because of sense of injustice or because of feeling of hostility toward the other group. (3) choice of target of aggression: the object of aggressive behavior -- whether persons or property symbolize the hostility of one group toward another.

According to our data, the riot is indeed much intensified during the 60s. The riot activities for the 70s and 80s become insignificant. Please see Table 1.

Table 1. Frequency Distribution of Riot by Month.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1964	1	2	1	1		1	2	3					10
1965			4		1	5	3	6		1	1		21
1966			1	1	2	3	8	5	2	1			23
1967			1	2	3	7	20	10	7	1			51
1968		1	2	13			10	5	8	1			40
1969			1	1	2	7	10	5	9	2	2	4	43
1970			1	1	3	5	7	10	2	1	6	1	37
1971		2			1	4	4		3	1	2	1	18
1972	1	1					1		1	1			5
1973						1		2					3
1974				1							2		3
1975						1	2	2					5
1976													0
1977								1					1
1978						1	1				1		3
1979				1	2	1	1						5
1980	1		1		3		4	2				1	12
1981												1	1
1982												1	1
1983			1										1
1984			1										1
1985												1	1
1986													0
1987													0
1988	1							1					2
1989													0
TOTAL													288

2.2 Frequency Distribution of Riot by Month

In the 60s, the phrase "long hot summer" has come to symbolize the increase threat of race-related civil disoreders during the summer months. We wish to find out whether the summer months really hold up its reputation as "long and hot" during the past 25 years. According to our findings, the phrase "long hot summer" indeed holds up its reputation. Let p be the probabiliky that the riot occurs in the summer. Then we wish to test that the riot equally likely occurs in either summer or non-summer months, namely, we have to test the null hypothesis against the alternative hypothesis given as follows:

$$H_0: p = 0.5,$$

$$H_1: p > 0.5. \tag{2.1}$$

The testing statistic is given by

$$\bar{z} = (\hat{p} - p)/\sigma\hat{p}. \tag{2.2}$$

From Table 2, we have by substituting $\hat{p} = 0.55$ and $\sigma\hat{p} = \sqrt{\hat{p}(1-\hat{p})/n} = \sqrt{0.55 * 0.45/288}$

$= 0.03$ into (2.2):

$$\bar{z} = (0.55 - 0.5)/0.03 = 1.67 \tag{2.3}$$

Using Table B on p. 673 of Loether-McTavish (1988), the one sided critical value of standard normal distribution at the 5% significance level is $z_{.95} = 1.65$. Since the computed z of (2.3) is greater than the critical value, the null hypothesis is rejected at the 5% significance level. Therefore, we conclude that the riot is more likely to occur in the summer months.

Table 2. Frequency Distribution of Riot by Month for the Entire 25 Year

MONTH	FREQUENCY	PERCENT
January	4	1
February	6	2
March	15	5
April	20	7
May	18	6
June	35	12
July	73	25
August	52	18
September	32	11
October	9	3
November	14	5
December	10	3
Total	288	98

Note. From Table 2, we obtain the following:

Spring (March, April, May): 19%

Summer (June, July, August): 55%

Autumn (September, October, November): 19%

Winter (December, January, February): 6%

2.3 Frequency Distribution of Riot by Weekday

A prevailing thought is that riots are most likely to be concentrated on weekend. From our data, we find out that the riots are more likely to occur over the weekend. Please see the following analysis.

Let p be the probability that the riot occurs over the weekend. Then we wish to test that the riot equally likely occurs over weekend or non-weekend. Again, we wish to test the hypothesis of Eq. (2.1). From Table 3, we obtain by substituting $\hat{p}$=0.55 and $\sigma\hat{p}=\sqrt{0.55*0.45/438}$=0.02 into Eq. (2.2):

$$\bar{z}=(0.55-0.5)/0.025=2.5 \tag{2.4}$$

Since the computed z of Eq. (2.4) is greater than the one-sided critical value $z_{95}=1.65$, the null hypothesis is rejected at the 5% significance level. Hence, we conclude that the riot is more likely to occur over the weekend.

Table 3. Frequency Distribution of Riot by Weekday for the Entire 25 years

WEEKDAY	FREQUENCY	PERCENT
Monday	76	17
Tuesday	88	20
Wednesday	56	13
Thursday	51	12
Friday	59	13
Saturday	48	11
Sunday	60	14
Total	438	100

Note. 1. The frequency distribution of riot by weekday for each year from 1964 to 1989 is given in Appendix 1.

2. From Table 3, we obtain the following:

Weekend (Friday, Saturday, Sunday, Monday): 55%

Non-weekend (Tuesday, Wednesday, Thursday): 45%

2.4 Frequency Distribution of Riot by Geography

By following the study of Lemberg Center, Brandeis University, we divide the United States into 9 regions to show its geographical distribution of race-related riots. The years we choose are 1967, 1968 and 19699. Three regions, South Atlantic, Middle Atlantic and East North Central accounted for 70% of civil disorders in 1967. In 1968, it is 57% of civil disorders. Overall, such a finding confirm the popular view of disorders as an urban, northern phenomenon. It is accurate to state that when the southern Blacks were struggling for Civil Rights Movements, the Blacks in the northern regions felt more hopeless and frustrated to change their ghetto situations. Please see Fig. 1a for the geographical distribution of riot on the next page. Note that the percentages of the nine regions in Fig.

1a is highly compatible with those of Fig.1b which is taken from Baskin, et al (1971).

3. POISSON MODEL

Consider events occurring in time on the interval 0 to ∞. For $t>0$, let N(t) be the number of events that have occurred in the interval (0,t), open at 0 and closed at t. Consequently, N(t) and for any $h>0$, N(t+h)-N(t). Assume only non-negative integer values.

We now make the following assumptions.

Axiom 0. Since we begin counting events at time 0, we define $N(0)=0$.

Axiom 1. The process $\{N(t), t>0\}$ has independent increments.

Axiom 2. For any $t>0$, $0<Pr\{N(t)>0\}<1$. In words, in any interval; (no matter how small) there is a positive probability that an event will occur.

Axiom 3. For any $t>0$,

$$\frac{Pr\{N(t+h)-N(t)\geq 2\}}{Pr\{N(t+h)-N(t)=1\}}=0$$

In words, in sufficiently small intervals, at most one event can occur; that is, it is not possible for events to happen simultaneously.

Axiom 4. The counting process N(t) has stationary increments; that is, for any two points $t>s>0$ and any $h>0$, the random variables N(t)-N(s) and N(t+h)-N(s+h) are identically distributed (Parzen, 1962).

By applyinjg the Poisson plot (Hoaglin, 1980), we can also estimate the rate of occurrence. To draw the least square line in the Poisson plot, we employ the regression subroutine of BMDP.

Let $x_0, x_1, x_2, \ldots,$ denote the counts of the observed frequency distribution and let

N = $x_0+x_1+x_2+.....$, we recall that the poisson probability function is

$$Pr(x=k)=p_\lambda(k)=e^{-\lambda}\lambda^k/k!, k=0,1,2,3,...$$

(3.1)

For a sample of N, the expected frequencies are

$$m_k=Np_\lambda(k)=Ne^{-\lambda}\lambda^k/k!, k=0,1,2,3,...$$

(3.2)

To derive the plot, we assume that for some fixed value of λ, each obsersved frequency, x_k, equals the expected frequency, m_k. Then taking natural logarithyms on both sides of (3.2) gives

$$\log(x_k)=\log(N)-\lambda+k\log(N)-\log(k!) \tag{3.3}$$

and it is evident that plotting $\log(x_k)+\log(k!)$ against k will yield a straight line with slope equal to $\log(\lambda)$ and intercept equal to $\log(N)-\lambda$. (If $x_k=0$, no point is calculated or plotted.)

If this "Poisson plot" for a set of data is satisfactorily stright, we may use the maximum likelihood estimator for λ:

$$\hat{\lambda}=\sum_k x_k/N.$$

From applying the regression plot to Table 4, we can say that the riot events are randomly distributed. I have run the entire 25 years of riots data by using BMDP regression subroutine to plot the fitted line and also estimated the slope of the line. The rate of occurrence of riot for each year is given in Table 5.

Table 4. Poisson Plot for Each Year From 1964 to 1989

Year	k	xk	logxk	logk!	logxklogk!
1964	0	347	5.85	0	5.85
	1	18	2.89	0	2.89
	2	0	-∞	0.69	-∞
1965	0	331	5.80	0	5.80
	1	30	3.40	0	3.40
	2	3	1.10	0.69	1.79
	3	0	-∞	1.10	-∞
	4	1	0	1.39	1.39
1966	0	336	5.82	0	5.82
	1	21	3.04	0	3.04
	2	8	2.08	0.69	2.77
1967	0	331	5.74	0	5.74
	1	39	3.66	0	3.66
	2	11	2.40	0.69	3.09
	3	3	1.10	1.10	2.2
	4	1	0	1.39	1.39
1968	0	307	5.73	0	5.73
	1	38	3.64	0	3.64
	2	15	2.71	0.69	3.4
	3	4	1.39	1.10	2.49
	4	0	-∞	1.39	-∞
	5	1	0	1.61	1.61
1969	0	323	5.78	0	5.78
	1	32	3.47	0	3.47
	2	9	2.20	0.69	2.89
	3	1	0	1.10	1.10
1970	0	315	5.75	0	5.75
	1	45	3.80	0	3.80
	2	4	1.39	0.69	2.08
	3	1	0	1.10	1.10
1971	0	341	5.83	0	5.83
	1	23	3.14	0	3.14
	2	1	0	0.69	0.69
1972	0	358	5.88	0	5.88
	1	7	1.95	0	1.95
	2	0	-∞	0.69	-∞
1973	0	362	5.89	0	5.89
	1	3	1.10	0	1.10
1974	0	357	5.88	0	5.88
	1	8	2.08	0	0.08
1975	0	356	5.87	0	5.87
	1	7	1.95	0	1.95

	2	2	0.69	0.69	1.38
1977	0	364	5.89	0	5.89
	1	1	0	0	0
1978	0	358	5.88	0	5.88
	1	7	1.95	0	1.95
1979	0	358	5.88	0	5.88
	1	7	1.95	0	1.95
1980	0	346	5.87	0	5.87
	1	18	2.90	0	2.90
	2	1	0	0.69	0.69
1981	0	364	5.90	0	5.90
	1	1	0	0	0
1982	0	363	5.90	0	5.90
	1	2	0.69	0	0.69
1983	0	364	5.90	0	5.90
	1	1	0	0	0
1984	0	362	5.89	0	5.89
	1	3	1.10	0	1.10
1985	0	362	5.89	0	5.89
	1	3	1.10	0	1.10
1988	0	363	5.89	0	5.89
	1	2	0.69	0	0.69

Table 5. Rate Of Occurrence For Each Year From 1964 To 1989

Year	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\lambda}=e^{-\hat{\beta}}$	
1964	5.85	-2.96	0.05	(every 20 days)
1965	4.92	-1.04	0.35	(every 3 days)
1966	5.40	-1.52	0.21	(every 5 days)
1967	5.24	-1.01	0.36	(every 3 days)
1968	5.03	-0.75	0.47	(every 2 days)
1969	5.50	-1.46	0.23	(every 4 days)
1970	5.53	-1.56	0.20	(every 5 days)
1971	5.79	-2.57	0.07	(every 14 days)
1972	5.88	-3.93	0.02	(every 50 days)
1973	5.89	-4.79	0.01	(every 100 days)
1974	5.88	-5.86	0.003	(every 333 days)
1975	5.31	-2.24	0.11	(every 9 days)
1977	5.89	-5.89	0.003	(every 333 days)
1978	5.88	-3.93	0.02	(every 50 days)
1979	5.88	-3.93	0.02	(every 50 days)
1980	5.74	-2.59	0.10	(every 10 days)
1981	5.90	-5.90	0.003	(every 333 days)
1982	5.90	-5.21	0.01	(every 100 days)
1983	5.90	-5.90	0.003	(every 333 days)
1984	5.89	-4.79	0.01	(every 100 days)
1985	5.89	-4.79	0.01	(every 100 days)
1988	5.89	-5.20	0.01	(every 100 days)

where $\hat{\alpha}$ and $\hat{\beta}$ denote the intercept and the slope of the least squares line fit to the data in Table 4 is shown in the following prediction equation:

$$\hat{y}=\hat{\alpha}+\hat{\beta}x$$

4. TWO-STATE MARKOV CHAIN

In this section we are trying to apply a two-state Markov chain in modeling the riot data. For the properties of two-state Markov chain, see Chapter 7 of Bhat(1984). Taking the city of Chicago as an illustrative example, the transition matrix of frequency counts are obtained for years from 1964 to 1968 given in Table.

Table 6. Transition Count Matrix for the City of Chicago

Year	f_{00}	f_{01}	f_{10}	f_{11}	$f_{..}$
1964	353	1	1	10	365
1965	348	1	1	14	364
1966	358	2	2	3	365
1967	344	3	3	14	364
1968	351	6	6	2	365

4. TWO-STATE MARKOV CHAIN

Let 0 and 1 denote two states of the Markov chain. State 0 means that the city of Chicago has no riot on a certain day, while state 1 means that the riot occurs in Chicago on that day. Then we start to count the transition between state 0 and 1 from January 1 till December 31 for each year. Therefore, if a year has 365 days, then the total number of transitions between states 0 and 1 is always 364 which is one less than the total number of days in a year, because there is no transition on January 1. In Table 6, f_{00} , f_{01} , f_{10} , f_{11} and $f_{..}$ denote the number of transitions from state 0 to state 0, from state 0 to state 1, from state 1 to state 0, from state 1 to state 1, and the total number of transitions in that year respectively. The transition count matrix for the year of 1964 is given by

$$\begin{bmatrix} f_{00} & f_{01} \\ f_{10} & f_{11} \end{bmatrix} = \begin{bmatrix} 353 & 1 \\ 1 & 10 \end{bmatrix}$$

What we are interested is whether the riot occurs in the city of Chicago from 1964 to 1968 are generated by the same unknown Markov chain. This can be done by testing the homogeneity of the transition count matrix between any two years from 1964 to 1968.

The testing statistics $2\hat{I}$, is given by

$$2\hat{I}=2\sum_{i=1}\sum_{j=1}\sum_{k=1} f_{ijk}\log(nt_{ijk}/(f_{i..}f_{.jk}))$$

$$=2\sum_{i=1}\sum_{j=1}\sum_{k=1} f_{ijk}logf_{ijk}+2nlogn-2\sum_{i=1} f_{i..}logf_{i..}-2\sum_{j=1}\sum_{k=1} f_{.jk}logf_{.jk}$$

The computed statistics $2\hat{I}$ between 1964-1968 is as following:

$$2\sum_{i=1}\sum_{j=1}\sum_{k=1} f_{ijk}logf_{ijk}=2(353log353+1log1+1log1+10log10+348log348+14log14)=8334.8$$

$$2nlogn=2\cdot 729\cdot log729=9610.7$$

$$2\sum_{i=1} f_{i..}\cdot logfi_{..}=2(365log365+364log364)=8600.2$$

$$2\sum_{j=1}\sum_{k=1} f_{.jk}logf_{.jk}=2(701log701+2log2+2log2+24log24)=9344.8$$

$$2\hat{I}=8334.8+9610.7-8600.2-9344.8=0.5$$

since r=2 and s=2, the critical value of Chi-square distribution with 3 degrees of freedom at the 5% significance level is $\chi^2_{.95}(3)=7.815$.

Note that the computed $2\hat{I}$ are greater than $\chi^2_{.95}(3)=7.815$, for all rows except the first row, we conclude that two-state Markov chains only for the years of 1964 and 1965 are the same, and all other years are different.

5. CONCLUSION

Most of the study on civil disorders were done in the late 1960s and early 1970s. For example, the Lemberg Center of Brandeis University has published several reports

on civil disorder, Spilerman(1970), Downes(1968), and etc. However, very few were done after the 70s, except McPhail-Wohlstein(1983). In this paper we analyze the riot data for the entire span of 25 years from 1964 to 1989. It is found that the riot are indeed more likely to occur in the summer months and over the weekend at the 5% significance level. After applying the Poisson plot, we notice that the riots viewed as events indeed constitute a Poisson process. Also, the rate of occurrence for each year from 1964 to 1989 are calculated. Finally, using the city of Chicago as an example, a two-state Morkov chain is built to model the riot data. It is found that the riots are not generated by a single unknown Markov chain.

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FINAL REPORT

Speaker Normalization and Vowel Recognition using Neural Networks

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Contract No.:	F49620-88-C-0053

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FINAL REPORT

CARDIO-RESPIRATORY MEASURES OF WORKLOAD DURING CONTINUOUS MANUAL PERFORMANCE

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FINAL REPORT

Development of a Localization Performance Paradigm for RHAW Applications

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Contract No:	F49620-88-C-0053

Development of a Localization Performance Paradigm for RHAW Applications

by

William D. Yee

ABSTRACT

An experimental paradigm was designed to assess the feasibility of using auditory localization in applied human performance situations. In order to provide a controlled and generalizable scenario, the paradigm integrated a hardware, software, and human factors approach. Initially, a brief survey of current Radar Homing and Warning (RHAW) systems in use for fighters and bombers was conducted to direct the design of the paradigm toward a real world application. Target acquisition was elicited as a key task that might benefit from the use of an auditory localization system to reduce response time. As a result, an ambient digit identification task was developed to evaluate the facilitative effects of an auditory localization system over the current usage of visual radar displays.

Acknowledgements

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. I would also like to thank Universal Energy Systems for coordination of the research program and assistance in transition to the base. I am also grateful for the support I received at the Armstrong Aerospace Medical Research Lab (AAMRL) in the Biological Acoustics Section from Dr. Charles Nixon and Dr. Thomas Moore.

I would also like to express my deepest gratitude to Mark Ericson for being the glue to the whole project during my stay. Without his untiring efforts, the project would still be a hypothetical construct. Additionally, David Ovenshire was a great boon in providing the technical and software expertise to make most of the equipment used a working reality. His staff at the Scientific Research Laboratory (SRL) provided the technical advice I needed to complete many parts of the project. This includes Dennis Allen and George Poulos for guidance and aid in hardware and Ron Dallman for key software support. Finally, I would like to thank Rich McKinley for providing the essential foundation for auditory localization and supplementing the project with valuable insights concerning its implementation.

I. INTRODUCTION:

Reliance on sensory inputs plays a major role in our interaction with the world. Such sensory information allows us to control both ourselves and events in the environment. However, there are situations that exist whereby an individual can not use all the sensory information naturally available. Common scenarios such as flying a plane or driving a car provide examples of how sensory information must be augmented via devices. Without mechanical aids such as radar displays, warning systems, mirrors, etc., control and mobility in planes or cars would be an extremely difficult task.

Given the fact that a pilot can only respond with respect to the level of accuracy of the equipment used and the information it provides, it naturally follows that enhancement of the sensory information would provide more precise control of the vehicle. To this extent, research has been ongoing at the Biological Acoustics Section of AAMRL on providing localization information auditorially. A suggested application could be to provide enhanced sensory information in a natural manner to the pilot to determine the location of airborne threats relative to his/her own position. This form of localization is expected to provide greater precision and faster responding in target acquisition than a conventional visual RHAW display.

Of course, my related interests in the area of the use and perception of auditory coding in human performance have provided me with some idea of the value of the ongoing research at the Biological Acoustics Section. In the past two years, most of the research that I had conducted related to auditory perception and attentional processes. I gather that this played a large part in my selection to work at the Biological Acoustics Section on a performance paradigm that would simulate and evaluate the application of an auditory localization system for target acquisition. In order to make a viable paradigm, I integrated areas familiar to my previous research experience (attentional processes, auditory perception, and human performance) into the research effort.

II. OBJECTIVES OF THE RESEARCH EFFORT:

At present, the applications of auditory localization have been practically non-existent. Although it has great projected utility in tasks like airborne target acquisition, research on the use of auditory localization has not proceeded much beyond the hardware development of a cue synthesizer (McKinley, 1988). A short study on the validation of the effectiveness of the cue synthesizer to provide accurate auditory localization information was recently completed (McKinley & Ericson, unpublished). However, no formal study has been implemented to assess a practical application of auditory localization by use of the cue synthesizer. As a consequence, movement to application of an auditory localization cue synthesizer has been quite lethargic.

Based on my research background, the best utility of my experience as a participant in the 1990 Graduate Student Research Program (GSRP) was to develop a feasible experimental project that would evaluate an applied approach to the implementation of the auditory localization cue synthesizer developed internally in the Biological Acoustics Section. At the outset, I drafted a project overview for a thorough experimental evaluation. Unfortunately, the size of the project drafted could not realistically be accomplished during the length of my contract. Given existing time constraints,

my effort was concentrated on developing and coordinating a general paradigm that would be used throughout the entire project. This included generating a flexible experimental design and the development and incorporation of needed hardware and software.

Additionally, I applied some effort toward designing the initial experimental protocols for the first series of experiments. The major impetus behind the first series of studies was to verify the effectiveness of the auditory localization system and to assess the contribution of different sensory modalities (both visual and auditory) in target acquisition. Later stages of the project will deal with the optimization of coded parameters, evaluation of operator confidence, and validation in field studies.

The first series of experiments are currently ongoing with the writing of this report. Construction of the experimental setup has been completed and debugged. Implementation of the first series of experimental protocols is also being arranged.

III. PROJECT IMPLEMENTATION:

The initial stage of the project development concentrated on identifying feasible applications of the localization cue synthesizer to be explored in empirical experimentation. To this end, several pilots were consulted on the possible implementation of such equipment in current RHAW systems. Information concerning single seat fighters and larger bombers seemed to suggest different approaches to the implementation of an auditory localization system in current RHAW systems.

Single seat fighters would have to emphasize greater speed and accuracy in their warning systems to aid in ambient target acquisition. Bombers require only coarse grained localization information for avoidance maneuvers. Bombers and larger aircraft may benefit to a moderate degree by the addition of auditory localization information, however, their key problems lie in communication lags between the electronic warning officer and the pilot.

It is apparent that direct benefits of auditory localization are more in line with the needs of single seat fighters. Consequently, the experimental paradigm was designed with the intent to evaluate how the addition of an auditory localization system may facilitate the effectiveness of a warning system over a conventional RHAW system. In

particular, one condition emphasizes ambient visual target acquisition analogous to a situation in which a pilot must visually acquire a missile plume to evade a missile. A second condition requires target acquisition without visual identification as might be the case in dark and low visibility scenarios.

A basic vigilance design was developed to simulate unexpected reactions to threat scenarios. Under this design, it was planned for subjects to provide performance data on response time and target accuracy in a situation that would present targets randomly in time and direction. Additionally, the design would compare performances of currently visually based RHAW systems to a system supplemented with auditory localization cues.

Finally, considerations were given to needed hardware and software that would allow for a reasonable experimental simulation of a RHAW system and an ambient target acquisition task. To this end, a Polhemus 3-Space Tracker was used to monitor head movements and targeting accuracy. To simulate ambient target acquisition, an array of 24 equally spaced LED display modules were mounted on a 4 foot high 14 foot diameter steel ring as indicated in figure 1. The displays were designed and built to provide a digit identification task to insure proper target identification. Visual targeting

information was presented on a CRT with a circular display. Auditory localization information was presented through stereo headphones by a cue localization synthesizer. All of the equipment was controlled by software through a Hewlett-Packard HP9845B microcomputer. The complete setup is shown in figure 2.

IV. RECOMMENDATIONS:

The basic design along with the hardware and software has been tested. Currently, the project is set to evaluate the effectiveness of the auditory localization system in supplementing the current RHAW system for a single seat fighter. However, modifications should be made later to evaluate the addition of the auditory localization system to other types of aircraft. This may include gathering data on how auditory localization could bypass some communication warning routes to aid a bomber pilot directly in evasive maneuvers.

Aside from the basic equipment and design, coding parameters will have to be tested in the future. Essentially, this would require optimizing the type of acoustic signals that would best serve for localizing. Prior research indicates that broadband noise can be easily localized when used as a source (McKinley & Ericson, unpublished). However, such forms of acoustic energy lack an ethological basis for attracting and holding a person's attention. Consequently, some form of empirical research must be conducted for optimizing response performance. This would also aid conventional RHAW systems which currently do not employ acoustic warning signals based on any systematic basis as evidenced by the inconsistency of the signals used across

several different RHAW systems.

Finally, some consideration should be given to moving the research to a field setting. The constrictive nature of pilot mobility in different aircraft may significantly affect the effectiveness of an auditory localization system. Additionally, high ambient acoustic noise levels in the cockpit may denigrate the efficacy of an auditorially based localization system. It would be prudent, even at this early stage, to at least begin some small field studies to evaluate the overall feasibility of implementing an auditory localization system. Furthermore, early field data may allow for corrections to be designed at the experimental stage.

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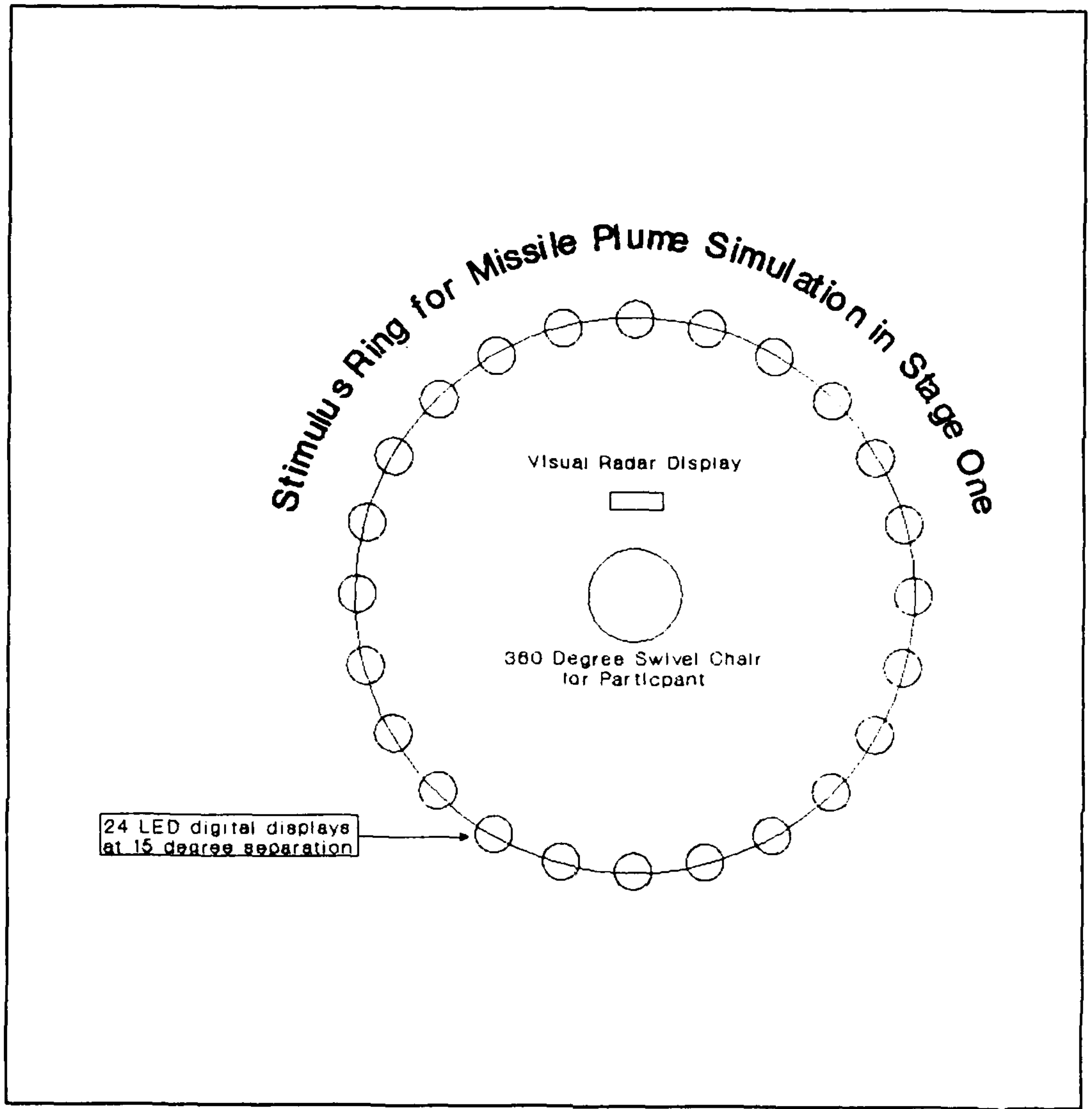
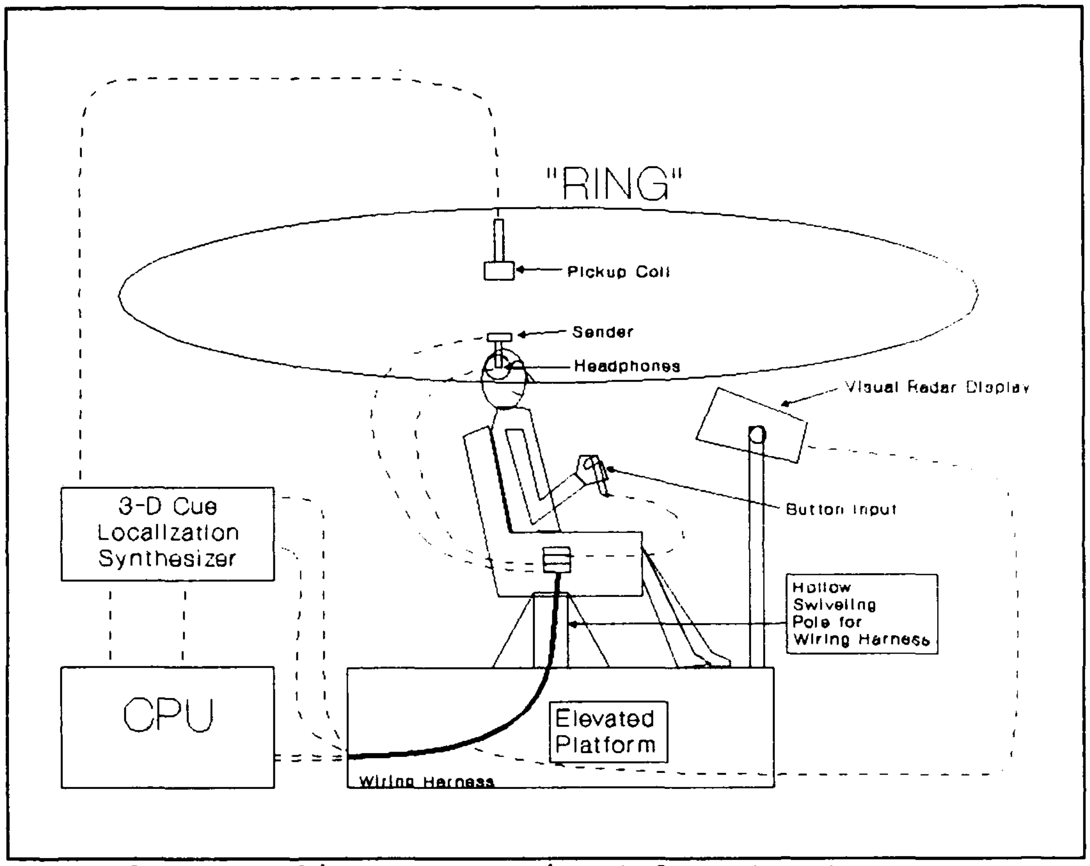


1. Positions of the 24 LED displays on the "Ring".



2. Hardware outline of experimental test setup.

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FINAL REPORT

A COMPARATIVE ANALYSIS OF A 4-GROUP AND 6-GROUP JOB CLASSIFICATION

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USAF Researcher:	William Alley, PhD.

Date:	July 27, 1990
Contract No:	F49620-88-C-0053

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Prof. Pinyuen Chen
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FINAL REPORT

A PILOT STUDY OF THE NAMING TRANSACTION SHELL

Prepared by:	Ann Marie Canfield
Academic Rank:	Graduate Student
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Research Location:	AFHRL, Brooks Air Force Base
USAF Researcher:	Michael Spector, Ph.D.

Date:	September 30, 1990
Contract No:	F49620-88-C-0053

A PILOT STUDY OF THE NAMING TRANSACTION SHELL

by

Ann Marie Canfield

ABSTRACT

The many hours required to develop quality computer-based instruction make it difficult to produce instruction that is both current and adaptable. Transaction Shells (Merrill, Li and Jones, 1990) provide novice instructional designers and computer users with tools to aid in the design and delivery of meaningful and easily modifiable courseware while dramatically decreasing the development time. This study was an initial pilot study designed to evaluate the effectiveness of the Naming Transaction Shell developed by M. David Merrill and Zhongmin Li at Utah State University. The major finding was that the predicted improvement in development time did occur. The software was tested at the Air Force Academy in Colorado by a subject matter expert with little computer and instructional technology expertise. The software was found to decrease development time and produce instructionally sound courseware. Recommendations from the subject include that future versions of the software contain more feedback parameters. Student record management, a feature not yet implemented, was strongly encouraged to be included in the next version.

ACKNOWLEDGMENTS

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems helped me in all administrative and directional aspects of this program. The Air Force Human Resources Laboratory at Brooks Air Force Base supported and hosted this research effort. The United States Air Force Academy in Colorado Springs provided a subject for the experiment and hosted a two week evaluation.

My experiences were positive and educational thanks to many different individuals. Dr. Mike Spector provided me with support and direction not only in my research, but also with all of the arrangements needed to make my stay in San Antonio and Colorado Springs enjoyable. Dr. Scott Newcomb, Dr. Mary Marlino and Maj. Milt Neilsen provided technical and administrative support that was greatly appreciated. I also wish to thank Capt. Kevin Crenwelge for being an excellent subject in my research. Drs. M. David Merrill, Zhongmin Li and the ID2 research team at Utah State University were invaluable to me and the success of this project through their support and encouragement.

I. INTRODUCTION

The need for corporate, military and industrial computer-based training (CBT) continues to rise. As a result of this rise, courseware developers and managers are confronted with the time-consuming aspect of the CBT development process (Faiola, 1989). Programming, debugging, and testing courseware is such a time-consuming aspect that efficient courseware development is an immediate concern (MacKnight and Balagopalan, 1988-89). The time required to develop one hour of computer-based training has been estimated to take anywhere from 200 to over 6000 labor hours (Carter, 1990; Lippert, 1989). These numbers make it difficult and expensive to produce current and timely CBT.

The Air Force is in the process of assessing the feasibility and effectiveness of developing a Transaction Shell approach to courseware authoring (Merrill, Li and Jones, 1990). This approach involves providing subject matter experts with tools to aid them in the design and delivery of effective, reusable and easily modifiable courseware. Transaction shells provide a novice designer with the ability to produce effective computer-based instruction (CBI) while dramatically decreasing the development time. Transaction Theory is a relatively new and innovative approach to courseware authoring developed by Dr. M. David Merrill and colleagues at Utah State University. The Navy has incorporated a somewhat similar idea in the Computer-Based Educational Software System (CBESS) (Wetzel and Wulfeck, 1987). Tennyson also has used a transaction-shell-like approach in Multi-International Language Instruction Module (MILIM) (Goldenberg and Turnure, 1989). However, Merrill's Transaction Theory provides a basis for generating a comprehensive library of transactions appropriate to courseware delivery (Merrill, Li and Jones, 1990).

The Air Force also has, as a long range goal, the development of an Advanced Instructional Design Advisor (AIDA). AIDA is a

courseware authoring advisor which will assist and guide military trainers through the process of effective computer-based instructional design. AIDA will take established theories of knowledge, learning, and instruction and incorporate the theories into course authoring (Muraida & Spector, 1990). The use of the Naming Authoring Transaction Shell is a first step in the implementation of the theories evolving in the AIDA research effort.

My academic background and experience in communication and ocmputer science education led me to the field of Instructional Technology. With great interest I have been pursuing graduate research on the Transaction Shell approach to courseware authoring. Prior to this particular research project, I have been working with Dr. M. David Merrill on identifying different kinds of transactions and the interactions required for each transaction in this project as an opportunity to validate some of the Transaction Shell research and development in progress.

Merrill and Li at Utah State University have developed a prototype Naming Transaction Shell for designing and delivering courseware for naming the parts and functions of a device. This transaction shell provides the user, a subject matter expert, with an environment which contains all of the relevant instructional strategies and expertise are built in. The user enters the appropriate content and the programmed strategy configures and delivers the instruction. Default parameters provide for delivery of the instruction with appropriate instructional values. However, the author can manually override the defaults for individual cases. For instance, the author may want to limit the response time during practice to five seconds instead of using the default setting, which in this case happens to be learner control.

The Naming Transaction Shell was the focus of this initial pilot study. The effectiveness of the environment and the feasibility

of incorporating the approach into the AIDA project needed to be determined. Results from this pilot study will be used by AFHRL to determine whether further and more comprehensive research should be planned in this area. The results indicate that Transaction Theory is a promising technology.

II. OBJECTIVES OF THE RESEARCH EFFORT

The objective of this research effort was to perform an initial formative evaluation of the Authoring Transaction Shell methodology and environment. More specifically, the research was aimed at evaluating the authoring mode and the perceived effectiveness of the delivery mode of the Naming Transaction Shell. Questions addressed by this experiment include the following:

1) Does the system reduce development time for computer- based instruction?
2) Is the environment appropriate for a novice computer user and novice instructional designer?
3) How would users like to see the system improved?
4) Was the environment acceptable to the authors?
5) Was the instruction acceptable to students?

The Air Force is interested in determining whether this type of system is a viable alternative to courseware authoring and whether it will fit into the scheme of the AIDA project. If the Transaction Shells do indeed reduce development time and produce meaningful software, a significant portion of the AIDA goals have been met.

III. METHODOLOGY

This initial experiment was designed to have one subject matter expert design and develop instruction for a portion of an

aviation course using the Naming Transaction Shell software. Broader and more conclusive studies will be scheduled based on the outcome of this initial study. The experiment took place at the Air Force Academy in Colorado. The instructional goal was to teach the names and functions of the instruments on the T-37 instrument panel. A two week period was allotted for the development of the instruction, with the subject matter expert working approximately half-time on the project. The subject was observed during his development time. The subject also kept a personal record of his thoughts and observations. At the end of each week, during the two week evaluation, a video-taped interview also recorded the subjects progress and thoughts.

The experiment was designed to test the usability, generalizability, executability and productivity of the Transaction Shell approach to courseware authoring. The development time required to produce courseware, both on-and off-line, and developmental obstacles were observed and recorded during the experiment. Observations which were made in these areas include:

1) How easily the user could adapt to the transaction shell environment.
2) The perceived versatility and utility by the user.
3) The user's assessment of student and instructor acceptability and user difficulties with the product.
4) Recommendations from the user for future versions of the software were also noted.

The software, Authoring Naming Transaction, was designed for use by subject matter experts who are novices in the area of CBI design. The user imports a graphic representation of the device to be taught. The individual parts are then identified and labeled. The function of each part is also defined by the user.

At this point, the module can be delivered to the student since all of the remaining parameters of a naming lesson contain default values. Figure 1 illustrates a sample student lesson screen.

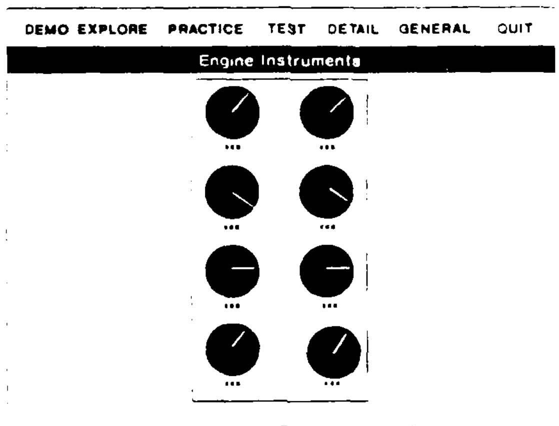

FIGURE 1. Student Screen

Default values are provided in order to automate delivery. A user, however, may desire to customize a lesson for a particular device or audience. The user can manually set all of the delivery parameters using the pull down menus. The software allows the user to select which student interaction modes to include in the actual delivery to the student (see figure 2). In some instances, testing may not be required, or the instructor may not want the student to have the option to interact in a particular mode.

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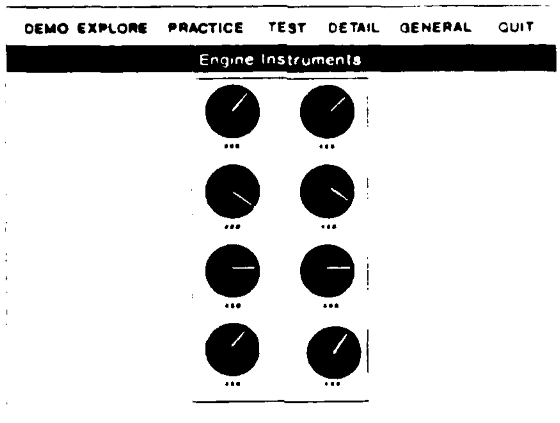

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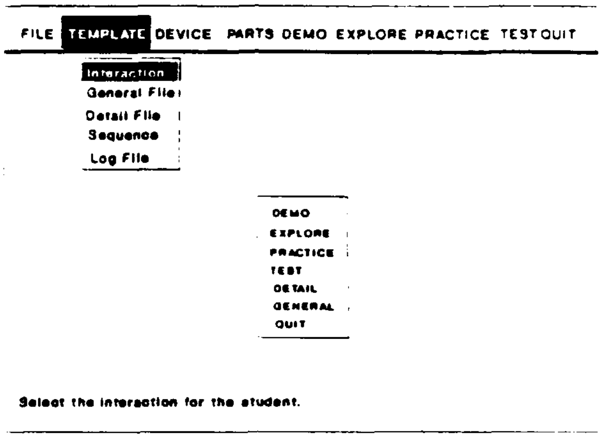

FIGURE 2. Author mode

Interaction parameters for the student during delivery can be modified and include:

Interaction	Description
Demo	System presents all of the parts and functions.
Explore	Allows the learner to control the presentation sequence of parts and functions.
Practice	The learner is presented a series of inquisitory instances with feedback.
Test	Learner is tested and scored on parts and/or functions names and locations.

Detail	Moves the learner to a more 'detailed' lesson of a particular part.
General	Moves the learner to a more 'general' or overview lesson

Additional values the designer may wish to manipulate are the timing (learner control vs. timed response) or sequence values (i.e., part name followed by function, part only, function only, function followed by part name) for the Demo, Explore and Practice options of delivery. There are also feedback parameters which can be modified. In the Test mode, the designer can select the sample size and criterion for success (e.g., 75%, 80%, 90% correct). The sample size refers to the number of times the student will be queried on each part during the test mode.

The modules can be linked together via general and detail files at any point during development. The user enters the file name to which the current file should be linked by a general or detail file. 'General' refers to higher in the hierarchical association, for example an overview lesson. 'Detail' refers to lower in the hierarchical association and may include a close-up view of a particular part with more 'details'nested beneath it.

The background of the subject was of particular importance in this study. The subject was selected based on his expertise in the subject matter. Captain Kevin Crenwelge was an instructor for the AV480 course which teaches the T-37 instrument panel used in this study. The subject was a computer and instructional design novice, which was the desired target audience for the study. His computer experience was limited to basic word processing. His instructional experience consisted of his having taught the course in a classroom setting on several occasions. In addition he had developed the course materials currently being

used in the classroom. He is presently responsible for several other AV480 instructors.

IV. RESULTS

At the end of the first week of work, the subject had completed four mini-lessons designed to teach and explore various aspects of the Authoring software. This introduction to the system took approximately five hours. The subject had also completed nine and one half hours of off-line design and development. This portion of the experiment included designing what would be taught, how the material would be grouped and a handwritten documentation of all design decisions. The subject relied on his own knowledge and Technical Order 1T-37 B-1 (T-37B Flight Manual) to determine lesson content. At the end of the first week of the experiment, the subject had dedicated fourteen and one half hours to the project.

The second week of the study began with completing the hand written design of the lesson content, which required two and one-half hours. The subject then selected the graphics he wanted developed for his instructional modules, this process will be detailed in a following section. With the written design and development completed, the on-line authoring began. After fourteen and one-quarter hours of on-line development time, the subject had completed the entire lesson package as designed. Twenty individual picture files and lesson sub-modules had been designed, ten detailed groupings which teach 125 parts and their functions.

The package was ready for delivery to students after a total of 31 hours of training, design and development time. A complete CBT package was completed in 31 hours by a subject matter expert with little instructional design or computer expertise. The package included the delivery of the instruction with testing

capabilities.

Figure 3 shows the ratio of on-line to off-line development time

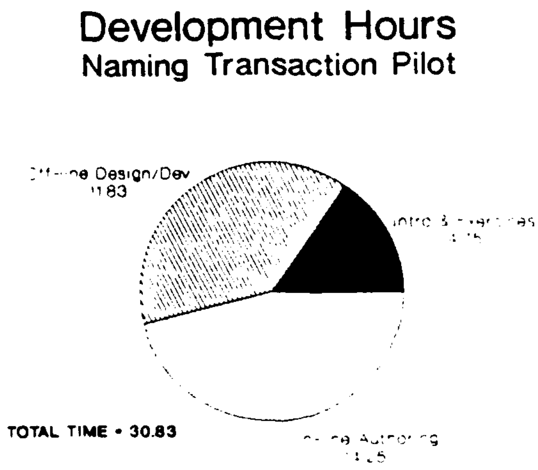

FIGURE 3. Proportions of Developmental Time

Individual module development time ranged from 5 to 25 minutes and included approximately five minutes of debugging or correcting time. Modules ranged in size from 2 parts to 10 parts, ten being the maximum allowed by the system. Linking the files together was also completed within the individual module development time.

Figure 4 illustrates development time in minutes versus the number of parts in an individual module.

Pilot Naming Transaction

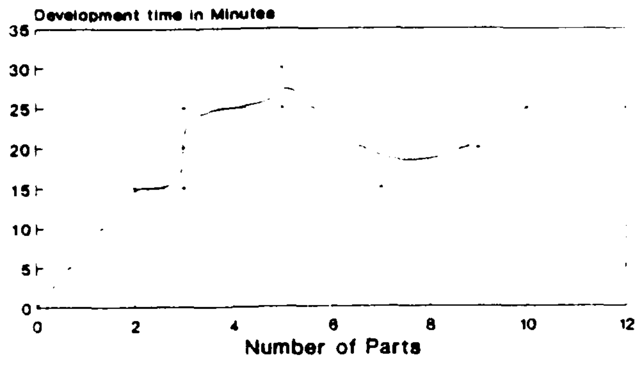

FIGURE 4. Number of Parts vs. Developmental Time

The student instructional time developed is estimated to be in excess of three hours of instruction. Actual data are currently being collected to confirm this estimate. Development time was 31 hours. The development to instruction ratio, therefore, is approximately ten hours of development per hour of student instructional time.

A reasonable comparison for development time is 200 hours under traditional software development methods (Lippert, 1989). Many authors cite development hours into the thousands (cf., Carter, 1990). The 200:1 ratio, from the low end of the scale, is used for comparison because we are omitting the graphics production on both ratios. The Transaction Shell development time is a significant decrease from the reasonable comparison of 200 hours identified with traditional software development (see figure 5). Although the ratio of 10:1 does not include graphics production, it does include selecting and directing the graphics development. Future versions of the Transaction Shell approach will put the development of graphical materials within the hands of the targeted user population.

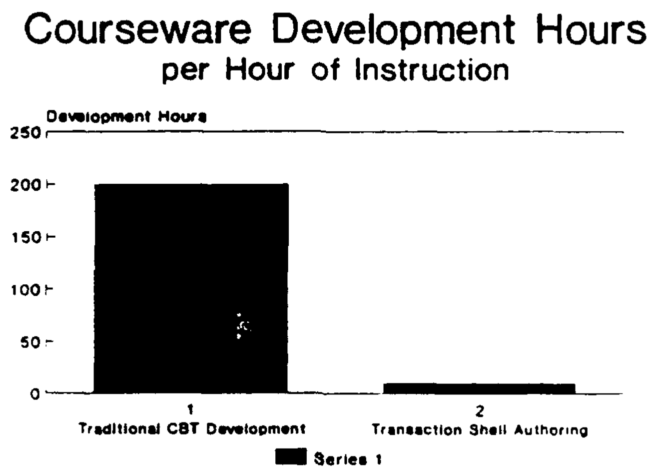

FIGURE 5. Comparison Development Hours

After completing an introduction to the system the subject was enthusiastic. He could see many applications for this type of software within the Academy. He felt the environment was easy enough that anyone would be able to use it and was excited to see what he could produce with the system. Traditional course development (non-computer) was much more laborious, he stated, and traditional CBT development was beyond the scope of his abilities. This new approach, according to the subject's observations, seemed more efficient and would improve student performance as well as motivation. There was some apprehension as to whether this approach to instruction would eliminate the jobs of some instructors.

At the end of the experiment the subject remained enthusiastic. He felt that anyone could learn to use the system both in design and delivery modes. Traditional course development (non-computer instruction) for the same material, in the subject's estimation, would have required at least two times the amount of development time. With the computer environment, he felt that the students would have higher motivation. The instructor could

ensure that a proficiency level had been reached before the student entered the simulator which would, as a result, decrease the amount of time in the simulator. It was difficult under the present non-computer system to ensure that students were studying and learning the material in the text. This often resulted in wasted effort in the simulator. By ensuring that the students knew the components and functions before they arrived, simulator time could be reduced and more students would be provided opportunities for training.

The subject enjoyed the time he had spent developing the instruction and was enthusiastic to share his accomplishments with co-workers and supervisors, who also had immediate positive reactions. Apprehensions about the computer taking over the role of instructors had been dropped as the software was now viewed as a tool to enhance the role of the instructor and would make their time more efficient. From the comments of supervisors, it was apparent that they were interested in the finished product. Every course taught in their division had a portion which could use this approach to instruction and benefit from the naming transaction. They were anxious for the next phase of the study and wanted to be included in the study. These reactions support the direction of AIDA research and development and indicate that further development of the Transaction Shell approach is warranted.

The default parameters for delivery seemed appropriate to the subject in most cases. He varied the parameters only slightly. The subject prefered to use timed presentations in the Practice interaction rather than the default of learner control. He also elected to modify the Testing parameters. He prefered a sample size of 3 and criterion level of 75% as opposed to the defaults of 2 and 90%. Interaction parameters were modified as appropriate to individual lessons. For instance, an overview module was designed to aquaint the learner with what lessons were available on the system. This module did not require testing, so

the Test Interaction was disabled.

V. SOFTWARE LIMITATIONS

Several limitations in the software were discovered and recommendations were made for future versions. The software had been developed as a prototype for demonstration purposes only. This study provided an opportunity to identify vital factors necessary for refining the robustness of the program for future studies. There were some problems with occasional mouse failure. This obstacle needs to be resolved before implementation can occur. The subject recommended that, in future versions, the author be given options to include different types of feedback during the test mode. At present there is no feedback during testing, only during the practice mode. Student record management was initially a feature planned for implementation in the next version. The subject strongly encouraged this addition which he felt would enhance the software. This feature will be implemented in the next version. In addition, the software is currently being modified to include data collection of time on tasks for both authors and students.

Limitations on descriptor size often made the development more difficult than necessary. Part names had a maximum length of 30 characters and the subject often had difficulty abbreviating the names of parts to fit this limitation. Part names often consisted of five or more labels. The function description was limited to five lines and this was thought to be occasionally restrictive. Instructional principles prescribe limiting the amount of knowledge placed in short term memory at any one point. Good instructional principles have been purposely built into the Transaction Shell so that instructionally sound CBT will be developed without the user having to be knowledgeable in the area of instructional design. However, the military technical orders the subject worked from to generate the lesson material dictated longer descriptors than would normally be recommended. This

conflict can be addressed by allowing larger descriptors than are recommended with defaults that encourage good instructional practices.

An additional discovery which prolonged the development was that each time a detail or general file is linked, the current file must be saved. Errors surfaced when all links within one file were made at one time. The subject found a solution to the problem, which added time to the development process. The subject's problem-solving approach in dealing with this problem, demonstrated his easily acquired knowledge and understanding of the system. This problem can be eliminated readily through more thorough preliminary system training and checks within the software to assure that the instructions are followed.

Several limitations in the graphic identification of parts were also discovered which may necessitate changes in the future. Some instances require identifying parts that are inside of other parts. Information nested for identification was not accessible during the Explore mode. However, this information could be accessed during the Demo, Practice and Test modes. The obvious, immediate solution is to omit the Explore interaction in these cases.

Identifying parts by location presented a difficulty for the subject when he wanted to group items that functioned similarly but were in separate locations on the screen. This limitation was overcome by grouping items by area instead of by function.

The subject was concerned also with how a student would know when all of the detail files available on the system had been completed. A student, if not careful, might miss some of the additional files. The subject felt some way of identifying what the student should accomplish or a map of where the student was in the system would be an important feature.

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VII. RESEARCH RECOMMENDATIONS

It is recommended that the transaction shell approach to courseware authoring receive further attention and research. After correcting the minor mouse and graphics problems, it is suggested that an experiment be conducted that involves more subjects, including students, and a variety of content domains. Factors that should be evaluated in future studies include learner outcomes, learner performance and courseware effectiveness. Traditional instruction and instruction generated by use of the Naming Transaction Shell for this study should be examined for their effect on the length of time required in follow-up simulator sessions.

Worksheets were used to help the subject in this study plan and organize his lessons. He noted that the worksheets were very beneficial. Automation of the worksheets would be an appropriate follow-up project which would advance the AIDA concept further. The worksheets and the exercises were developed as the experiment progressed. Future experiments should allow for job-aid and training development preceding the experiment, with ample time for revision in order to produce higher quality job-aids and training. A future study should also include the Procedure Transaction Shell currently being developed at Utah State University for the Air Force Human Resources Laboratory.

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FINAL REPORT

AUTOMATING THE ADMINISTRATION OF USAF OCCUPATIONAL SURVEYS

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USAF Researcher: John Price, SqdLdr (Australia), AFHRL/MOD

Date: July 11, 1990

Contract No: F49620-88-C-0053

Same Report as
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(Report # 136)

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FINAL REPORT

Psychophysical Measurement of Spectral Attenuation in the Human In Vivo Ocular Media: Method and Results

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(Report # 137)

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FINAL REPORT

An Examination of Factors Influencing Air Force Enlisted Retention

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Date:	13 September 1990
Contract No:	F49620-88-C-0053

An Examination of Factors Influencing Air Force Enlisted Retention

by

John E. Holman

ABSTRACT

The purpose of this project is to identify factors which lead to voluntary enlisted separation in the U.S. Air Force. A data set was provided by Dr. Thomas Watson of the Air Force Human Resources Laboratory which included 3,998 first and second-term enlisted personnel in eight Air Force specialties. Multiple regression was used to estimate a path model based on the work of Holman (1989), Price and Mueller (1981 and 1986), and Watson (1985). Recommendations based on the findings are given, followed by a discussion of future research possibilities.

Acknowledgements

I would like to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsoring this research. Universal Energy Systems was also very helpful with the administrative aspects of this project.

Everyone at the Human Resources Laboratory at Brooks Air Force Base was extremely helpful, cooperative, and friendly. Cal Fresne and TSgt Wayne Dooley of the Computer Programming branch were instrumental in updating the data set. They accomplished in days what would have taken others months, and their insightful comments and suggestions were greatly appreciated. The help and friendship of Linda Sawin and Malcolm Ree were also appreciated. Lt Steve Armstrong provided valuable technical assistance, and LtCol Roger Alford and William Alley were always there to help with administrative details.

A special thanks goes to Tom Watson. His data set was of course key to this project, but the project would have been impossible without his suggestions, encouragement, and friendship.

James Price was also a central figure in this research. His knowledge of the retention area greatly facilitated this project. I would also like to thank Charles Mueller for his technical advice throughout the project.

Finally, I would like to thank Tanya Uden-Holman. Her statistical and theoretical knowledge and constant encouragement made this project feasible and meaningful.

I. INTRODUCTION:

Personnel retention is one of the more thoroughly examined areas in personnel psychology. Interest in retention has waxed and waned, but the basic tenet of personnel research- select the best people possible and keep them- has remained relatively constant. In the face of cutbacks, it is increasingly important for the Air Force to attract, select, and retain people of the highest possible quality.

The Manpower and Personnel division of the Air Force Human Resources Laboratory (AFHRL) has a long history of research in both personnel selection and retention. My master's thesis reviewed the literature dealing with military retention, and much of the work I reviewed was conducted at AFHRL. The purpose of this project is to build upon my thesis by using an existing Air Force data set to merge the existing work in military retention with an established model of civilian retention.

My research interests lie mainly in the two-pronged selection/retention process. In addition to my master's thesis, I have participated in several projects dealing with employee retention, absenteeism, and performance. The past four years of my graduate work have given me the opportunity to work with two well-known scholars in my two areas of interest. Professor James L. Price has worked in the area of civilian personnel turnover for many years, and is considered one of the foremost authorities in the area. Professor Frank L. Schmidt is a leading authority in the area of personnel selection and staffing, and is also a specialist in psychometrics.

II. OBJECTIVES OF THE RESEARCH EFFORT:

The main objective of this research effort is to identify the factors which lead to voluntary enlisted separation in the US Air Force. Once these factors are identified, steps can be taken (at the discretion of policy makers) to foster working conditions which encourage higher retention. Knowledge of the determinants of retention can also help predict future retention rates and predict the impact of policy, social, and macroeconomic changes.

As stated in the introduction, personnel retention has long been a topic of concern for both military and civilian managers. Military research in this area has often focused on demographic factors (i.e., age, race, sex) and excluded psychological, economic, and structural factors. This study, drawing upon the work of Price and Mueller, focuses on the latter. Demographic variables are useful for prediction, but carry little explanatory power. In addition, demographic variables are usually more difficult to manipulate than other types of variables (e.g., it is easier, both practically and legally, to change working conditions than employees' age, sex, or race).

III. SAMPLE:

The data for this study were provided by Dr Thomas W. Watson of AFHRL. In 1983 Watson sampled first and second-term enlisted personnel serving in one of eight Air Force specialties (AFSs). The final sample consists of 3,998 subjects, with an overall response rate of 56 percent. The data set was updated by the computer programming division of AFHRL in the summer of 1990. By this time, all the subjects had had the opportunity to make a stay/leave decision. Four new variables were added to the existing data set: 1990 stay/leave status; Date of Separation;

Reason for Separation; and Category of Enlistment (first-term, second-term, or career airman).

Since this study focuses on voluntary separation, involuntary leavers (n=577) were excluded from the analysis. After listwise deletion for missing data, the sample dropped another 255 cases, leading to a final sample size of 3,166 for the full model. 1,232 subjects left the Air Force, while 1,934 were retained.

IV. MODEL:

The model of retention used in this study is based upon three existing models: Price and Mueller's model of civilian turnover, Watson's model of enlisted retention, and Holman's model of military retention. These models use psychological, structural, and economic variables to explain voluntary separation decisions at the individual level.

V. MEASUREMENT:

Each of the subjects was mailed the USAF Retention Survey (USAFRS), a questionnaire developed by Watson for the original study. The USAFRS is composed of 154 items, and primarily measures attitudes and perceptions about job characteristics and outside job opportunities.

The first step of the project was to examine Watson's work and identify his a priori and empirically derived scales. Some of Watson's concepts were not used in this analysis in order to remain as consistent as possible with the civilian literature and to keep the model as parsimonious as possible. A few items were added or deleted

from some scales, and some scale names were altered to reflect changes in the field since 1985. Table 1 shows the names and definitions of the scales used in this study.

Since the USAFRS is not a standardized instrument, exploratory factor analysis was used to test the discriminant and convergent validity of the hypothesized constructs. With few exceptions, the hypothesized factor structure was retained.

The next step was to compute the scale reliabilities. Since all the constructs are measured at one point in time, Cronbach's alpha was used to assess the internal consistency of each scale. The results of this analysis can be seen in Table 2.

VI. RESULTS:

Path analysis was used to estimate both the hypothesized model and the trimmed empirical model. OLS regression (SPSS-X Version 2.0 and 3.0) was used to estimate the model through Intent to Stay. Since Retention is a dichotomous variable, logistic regression (SYSTAT Logit module) was used to estimate the final stage of the path model. The results of these estimations are presented in Table 3 and Table 4.

As seen in Table 3, the hypothesized model fits the data reasonably well. Two hypothesized paths were not significant, however. Distributive Justice and Work Group Cohesion did not significantly affect Commitment to the Air Force. These paths were omitted and a second, trimmed path model was estimated. This model fits the data as well as the original hypothesized model, and all the paths are significant.

Table 1. Variable Definitions

Air Force Satisfaction	The degree to which an individual likes or identifies with the Air Force/military way of life
Alienation	The degree to which an individual feels they have control or "say" in their job
Commitment to the Air Force	The relative strength of an individual's identification with and involvment in the Air Force
Communication	The degree to which information is transmitted among organizational members
Intent to Stay	An individual's perception of the likelihood of continued membership in the Air Force
Job Satisfaction	The degree to which individuals like, or have a positive affective orientation toward their job
Kinship Responsibility	The degree of an individual's obligations to relatives in the immediate community
Opportunity	The perception and evaluation of the availability of alternate jobs in the organization's environment
Pay	Remuneration received by employees for carrying out their duties
Promotional Opportunity	The degree of potential vertical occupational mobility within an organization, also known as "internal labor markets"
Routinization	The degree to which a job is repetitive
Support	The support for continued military membership received by the member from spouse, family, and/or friends

Table 2. Reliability Analysis of Constructs (Cronbach's Alpha)

Construct Name	Number of Items	Reliability Coefficient
Air Force Satisfaction	2	.846
Autonomy	2	.718
Commitment to the Air Force	10	.861
Communication	7	.828
Distrubutive Justice	3	.680
Intent to Stay	4	.950
Job Satisfaction	3	.787
Opportunity	6	.831
Promotional Opportunity	2	.521
Routinization	3	.661
Support	2	.565
Work Group Cohesion	3	.763

Table 3. Path Analysis Results: Initial Model (standardized coefficients)

Independent Variable	Dependent Variable: Satisfaction	Commitment	Intent	Retention
AF Satis.	----	.496***	----	----
Alienation	-.097***	-.199***	----	----
Cohesion	.094***	.006	----	----
Communication	.166***	.088***	----	----
Dist. Justice	----	.001	----	----
Kinship	----	----	.135***	.390**
Opportunity	----	-.047***	-.349***	-.135*
Pay	.043**	----	----	----
Promo. Op.	.042**	.085***	----	----
Routin.	-.382***	----	----	----
Support	----	----	.140***	----
Job Satis.	----	.128***	----	----
Commitment	----	----	.399***	----
Intent to Stay	----	----	----	.651***
Constant	13.470	1.457	2.285	1.914
R^2	.292	.547	.356	.259
Adjusted R^2	.291	.546	.356	.258

*** $p < .001$
** $p < .01$
* $p < .05$

Table 4. Path Analysis Results: Trimmed, Empirical Model (standardized coefficients)

	Dependent Variable			
Independent Variable	Satisfaction	Commitment	Intent	Retention
AF Satis.	----	.495***	----	----
Alienation	-.095***	-.200***	----	----
Cohesion	.093***	----	----	----
Communication	.163***	.088***	----	----
Kinship	----	----	.135***	.390**
Opportunity	----	-.047***	-.349***	-.135*
Pay	.042**	----	----	----
Promo. Op.	.040*	.085***	----	----
Routin.	-.384***	----	----	----
Support	----	----	.140***	----
Job Satis.	----	.129***	----	----
Commitment	----	----	.399***	----
Intent to Stay	----	----	----	.651***
Constant	13.341	2.201	2.285	1.914
R^2	.291	.547	.356	.259
Adjusted R^2	.290	.546	.356	.258

*** $p < .001$
** $p < .01$
* $p < .05$

Routinization was the most important determinant of Job Satisfaction. Next was Communication, followed by Alienation, Work Group Cohesion, Pay, and Promotional Opportunity respectively. Air Force Satisfaction was the most important determinant of Commitment, followed by Alienation, Job Satisfaction, Communication, Promotional Opportunity, and Opportunity. Commitment to the Air Force was the most important determinant of Intent to Stay, followed by Opportunity, Support, and Kinship Responsibility. Intent to Stay was the strongest predictor of Retention, followed by Kinship Responsibility and Opportunity.

VII. RECOMMENDATIONS:

The purpose of this paper is to use past work in retention to build a model which does a reasonable job of explaining Air Force enlisted retention. Although many of the variables do not lend themselves to manipulation, four findings stand out as possible candidates for policy consideration. It would, of course, be up to policymakers to determine whether these findings can truly be implemented in some way.

The strongest finding is that Air Force Satisfaction increases Commitment to the Air Force. Since Air Force Satisfaction may be largely determined pre-entry, it may be fruitful to seek personnel who would enter the Air Force with relatively high Air Force Satisfaction (e.g., people from military families). Perhaps a personality inventory could be designed which taps this concept in applicants.

The second strongest finding is that Routinization decreases Job Satisfaction. Perhaps the various Air Force specialties could be examined for ways of increasing variety on the job.

The third strongest finding is that Alienation reduces Commitment to the Air Force. Something along the lines of participative management techniques might reduce feelings of alienation and thus increase Commitment.

The fourth strongest finding is that Communication increases Job Satisfaction. Keeping personnel as well informed as possible and allowing them some input (e.g., a suggestion box) may increase Job Satisfaction (and may have the side effect of reducing Alienation).

VIII. FUTURE WORK:

This project should be viewed as a preliminary report. There are many more steps that should, and hopefully will be taken. One of these steps is to look for theoretically meaningful moderator variables. With the wealth of demographic information in Watson's data set, potential moderators such as age, gender, grade, AFS and tenure can be explored.

A strength of the updated data set is that all subjects have had the opportunity to make a stay/leave decision. One probable effect of the relatively large time frame between the administration of the questionnaire and the measurement of stay/leave decisions is lower explanatory power and thus the moderate R^2 for the actual Retention model. It might be helpful to move the cutoff for stay/leave decisions closer to the date of questionnaire administration, discarding subjects who had not had the opportunity to make a decision.

The number of involuntary leavers (577) should provide sufficient statistical power to examine how well the model works for involuntary leavers. Since the model was

developed to explain voluntary turnover, one would predict a poorer fit when the subjects are involuntary leavers.

As stated earlier, the current model is an attempt at a general model of retention. A test of its generality would be to include determinants which are more sample-specific. Some examples are Watson's variables "Bonus Adjustment Sensitivity", "Impact of Assignments", and "Importance of Air Force Benefits". If including these variables substantially improves the model's fit, then the generality of the original would be called into question.

Future analyses of this data set should use LISREL to estimate the path model (LISREL was not used for this report due to software and hardware limitations). LISREL is becoming the method of choice for path analysis because it simultaneously estimates a measurement model and a structural model. An additional benefit of LISREL is that path coefficients are corrected for measurement error.

Event history analysis is another technique which is increasingly being used in turnover/retention work. The advantage of event history analysis is that the effect of time can be modeled. Traditional retention work looks at a specific frame of time and splits the sample dichotomously into stayers and leavers. Event history analysis not only looks at who stays and who leaves, but also how long the leavers worked before leaving. A word of caution is necessary for military retention research: event history analysis assumes time to be a continuum and that an event (quitting) can occur at any point in time. The military has explicit terms of employment, and members cannot simply leave at will. Researchers who wish to use event history analysis for military retention work may want to consider modeling time as a

discrete phenomenon, i.e., as a series of reenlistment decisions throughout an individual's career.

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FINAL REPORT

Cognitive Representations of Teams

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Contract No:	F49620-88-C-0053	

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FINAL REPORT

Peripheral vs. Foveal Contour Processing in Humans

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Date:	19 Sept 90
Contract No.	F49620-88-C-0053

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The research we did was fruitful only because of the help of many people in the lab. Dr. George A. Geri provided much guidance and hard work from the design to implementation of the study. In addition, much thanks are due Trish Russo, whose unabated work on the stimuli really made the project possible. Additional thanks for support and suggestions are due Dr. MaryLou Cheal, Dr. Don Lyon and Dr. Paul Wetzel.

I. INTRODUCTION:

The coding and processing of contours is important to a full understanding of form perception by the human visual system. Fourier descriptor research provides a way of quantifying a contour and therefore provides a way of relating the phenomena associated with exposure to contours to other visual phenomena.

We have been involved, for the past two years, with the study of edge detection and have used an adaptation paradigm to study the perception of simple curves.That research has shown us that the perception of even simple curves is intricately related to the complexities of contour processing in humans. We have also had experience with the numerical solution of partial differential equations (PDEs). Given our technical backgrounds we recognize the necessity for an objective measure of stimulus shape. Such a measure has not been used in the curvature adaptation research to date. In addition, we comprehend the complexities involved in the numerical solution of physical and psychological problems. This is definitely needed to do Fourier Descriptor research.

At the Human Resources Laboratory at Williams Air Force Base there has been much work done involving Fourier descriptors and contour perception. Recently their work has centered around distinguishing the differences between contour perception in the fovea and in the periphery. Our previous work with perception of and adaptation to simple curves is related to peripheral vs. foveal contour perception. We have exposed human subjects to curves which are adjusted by the subject and change from peripherally based to entirely foveal.

II. OBJECTIVES OF THE RESEARCH EFFORT:

Although Fourier descriptors have proven to be an excellent way of quantifying stimulus shape and have been shown to be moderately easy to generate (Kuhl and Giardena, 1982), very little has been done with this method in psychophysical experiments. In addition, whether the amplitude of the Fourier descriptors is a valid metric only for the fovea and must be modified to accommodate increasing eccentricity still remains an open question. Geri and Lyon (1990) did find that, as eccentricity was increased, it was necessary to correct with a cortical magnification factor (CMF) in order to obtain the same sensitivity in the periphery as in the fovea.

Thus we decided, along with our research supervisor, to work in the periphery with contour stimuli. We decided to see how sensitivity to differences in the phase between two stimuli changed with foveal versus peripheral presentation. The basic Fourier Descriptor research gave us a means of generating stimuli whose harmonic frequency, amplitude and phase could be varied.

After investigating various methods for generating Fourier Descriptor stimuli (e.g. Zahn and Roskies, 1972 and Kuhl and Giardina, 1981) we decided on a simpler means of generating the stimuli, using polar plots. In addition we decided to vary the phase of our stimuli and to test in the fovea and in the periphery at 40° eccentricity.

Upon completion of the project we took data from 2 observers and were able to measure the change in sensitivity with respect to phase and eccentricity.

III. METHODS:

The observers were 2 researchers at HRL. One (JW) was a 22 year old female graduate student. The other (GG) was a 39 year old male member of the HRL research staff .

The stimuli were rose curves (Selby, 1968) which were added to a circle of radius q. The functional expression for the curves was:

$$r = a \cdot \cos(n\Theta) + b \cdot \sin(n\Theta) + q \tag{1}$$

where, assuming that the value of q is sufficiently large, the number of leaves is determined by n. The size of the individual stimuli is determined by the magnitude of a and b and the phase by the ratio of a to b. Since there are sin like undulations around a circle, the rose curve with n=3, for instance, can be described as having 3 cycles/perimeter and will be referred to as a 3rd harmonic. Fig. 1 shows the components of an example stimulus.

The stimuli used in the study were composed of a 3rd harmonic at one of three different phase angles, added to a circle and then to a 4th, 6th or 9th harmonic each also at one of set of phase angles. Shown in table 1, are the combinations of harmonics and phases used to create the stimuli for the present study. Figure 2 shows some typical stimuli and identifies their components.

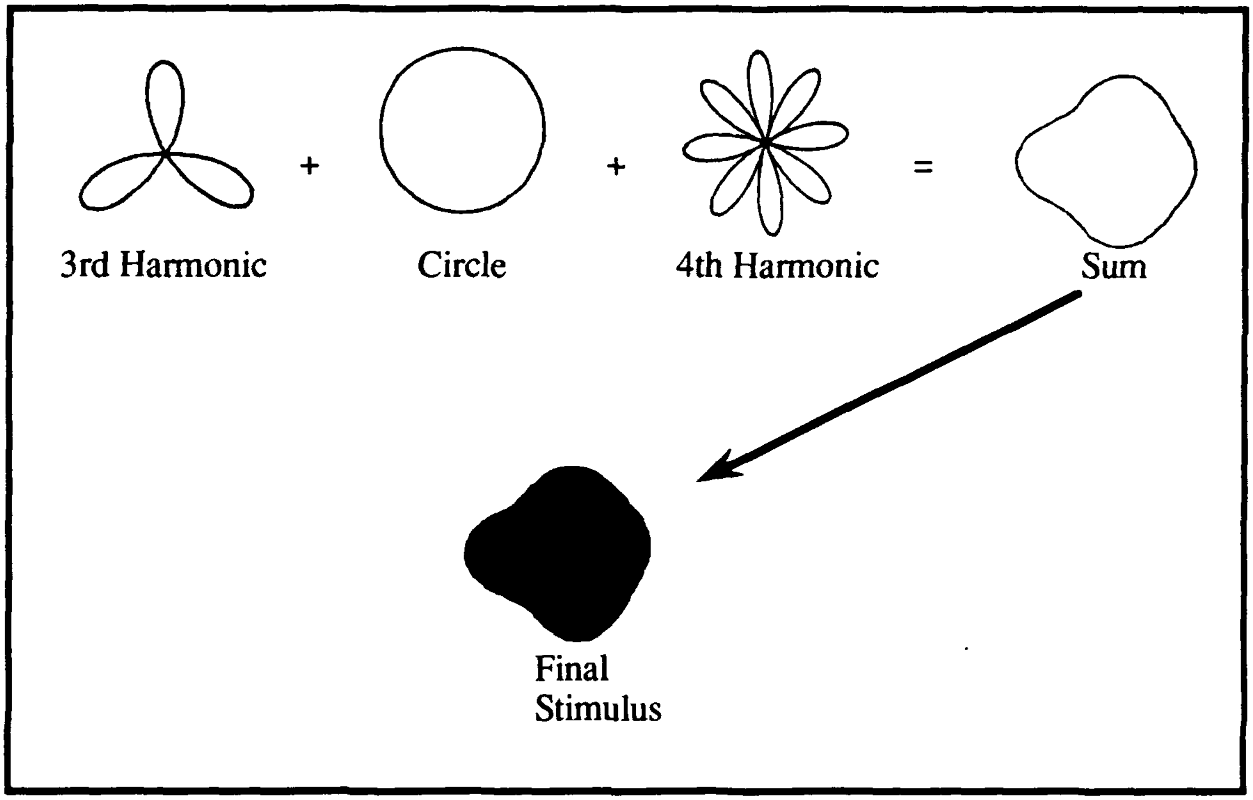

Figure 1: A progression showing the components of an example stimulus

	n = 3	n = 4	n = 6	n = 9
Phase Angle	30°	22.5°	15°	10°
	70°	40.5°	27°	18°
	110°	58.5°	39°	26°
		76.5°	51°	34°
		94.5°	63°	42°

Table 1: Stimuli were composed of a 3rd harmonic at one of the three phases added to one of the other harmonics at one of its 5 phases.

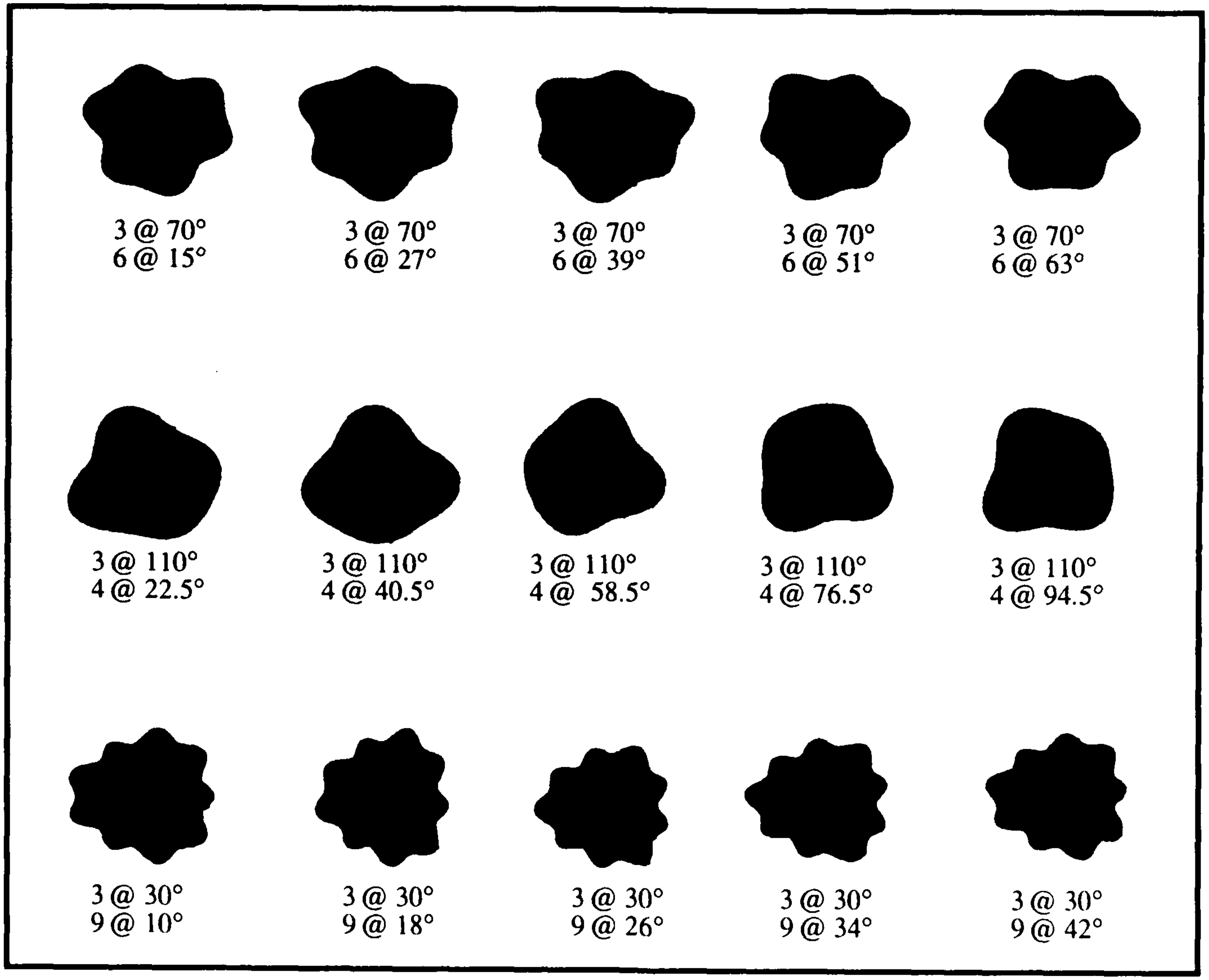

Figure 2: Some samples of stimuli, each with its components and their phases listed.

The stimuli were presented on 35mm slides. The apparatus for stimuli presentation and observer response consisted of 2 slide projectors, 2 frosted screens set in front of them and an observer response station in front of the two screens. For the foveal condition the stimuli were 0.64° of visual angle across and were projected on one screen and separated by 1.25° corresponding to an eccentricity of 0.75°. For the peripheral condition the stimuli were 17.2° of visual angle across and were projected on two screens and separated by 80° corresponding to an eccentricity of 40°.The experimental chamber was kept completely dark except for the light from the projectors. The dark images which the subjects viewed were 0.1 ft/lamberts and the light surrounding them was 10 ft/lamberts.

IV. PROCEDURE:

The subjects were shown 720 presentations of stimuli in each of 6 sessions. During 3 of the sessions they were given the foveal condition and during the other 3 they were given the peripheral condition. They were shown pairs of stimuli which they were instructed to judge for similarity. The standard stimulus was a 3rd harmonic at one of the three possible phase shifts added to one of the higher harmonics at its lowest phase shift. The comparison stimulus was the same combination of harmonics as the standard except with a different phase for the higher harmonic component. It is important to note that the phase of the 3rd harmonic was always the same between the pair to be judged. The stimuli were both presented at the same time for 0.2 seconds. Subjects responded by rating the similarity on a scale of 1 to 5. At the same time subjects pressed one of two keys which recorded a response of same or different in a computer. These two responses were later compared for accuracy. Rating responses were always recorded by one of the experimenters.

Each session lasted about 45 minutes and subjects had at least another 45 minutes in between sessions. In addition, the rate of stimuli presentation was self paced and subjects took a few moments rest when they felt tired.

V. RESULTS:

In general, even with a CMF of 26.9, sensitivity in the periphery, as measured by percent correct vs. percent wrong, was not as high as in the fovea. In addition, in both subjects the sensitivity went down to a level approaching chance for the 3rd, 9th harmonic combinations in both foveal and peripheral conditions. This would follow as these stimuli had much more complex contours (see Fig. 2, bottom row). Also, changes in the phase of the 3rd harmonic had no significant effect on perceived similarity. So, throughout the rest of this paper results specifying phase will always be in reference to the higher harmonic component.

For the foveal condition, both subjects were most sensitive to differences between the 3rd, 4th harmonic combination. Both showed very high degrees of sensitivity with comparisons to the base and 58.5° and above. Sensitivity went back down with phase change above 76.5°. For the 3rd, 6th harmonic combination the results were similar, with sensitivity peaking at 34° and being lowest at 18°. Peak and low sensitivities could not be determined for the 3rd, 9th harmonic combination, as the sensitivity functions clustered in the same spot, just above chance for JW and around chance for GG.

In the peripheral condition the sensitivity functions were not as spread out and it was not possible to determine the peak or low stimulus conditions. However both subjects were able to discern differences between the 3rd, 4th harmonic stimuli with considerable accuracy. This accuracy dropped off considerably with the 3rd, 6th harmonic stimuli and

clusters around chance for the 3rd, 9th harmonic condition. Again, in general sensitivity is not as high for the peripheral conditions despite the very large CMF.

VI. RECOMENDATIONS:

The results of this research suggest the need for a couple of detailed investigations. First there is the need to investigate the apparent difference between foveal and peripheral discrimination of contour stimuli. The fact that such a large CMF (26.9) was not able to account for these differences suggests that they have less to do with the reduced acuity in the periphery and perhaps more to do with a fundamental difference between fovea and periphery in the way these two areas handle contours. Also, it would seem wise to continue to investigate the way the visual system processes more complex stimuli as it may be that adjusting parameters such as the length of presentation interval may bring the discrimination of more complex stimuli (such as ours containing a 9th harmonic) up to a level comparable to that for simpler stimuli.

It might also, prove fruitful to implement a descriptor model using a generation scheme similar to the one used in this research. This would be advantageous for a couple of reasons. First, this model has the advantage of generating homogeneous harmonics across different base figures. The current methods generate different harmonics for different coded stimuli. This method could be much more general. This will become important in the investigation of the differences between peripheral and foveal contour processing since a very specific model may (and in deed has) over looked such differences. Second, but certainly not of secondary consideration, is the fact that this model would be considerably simpler than the current one. This simplicity comes in handy when the model is extended to consider the wide range of types of vision like peripheral to foveal. As the range of processes the model is developed to reconcile widens so will the complexity of the model

and the calculations associated with it increase. An initial simplicity will go a long way toward ensuring that the complexity does not grow to large to handle.

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FINAL REPORT

Cognitive Determinants of Graph Reading Skill

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Date:	10 Sept 90
Contract No:	F49620-88-C-0053

Cognitive Determinants of Graph Reading Skill

by

Carol S. Soulé

ABSTRACT

This study investigates graph reading skill by examining some of the associated underlying cognitive determinants. The general theoretical framework that guides this study suggests that working memory, general knowledge, and prior specific knowledge of graphs predict graph reading skill proficiency. The data were collected from 300 Air Force recruits. A test battery was administered that included tests of prior knowledge, general world knowledge, working memory, as well as a general learning task of graph reading skill. Results indicate that within the theoretical framework, working memory, general knowledge, and specific prior knowledge together provide a model that depicts general learning of graph reading skill.

Acknowledgements

I would like to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research and my participation in the Summer Research Program. The administrative support of Universal Energy Systems is also appreciated.

Patrick Kyllonen provided support and direction through all phases of this research. Valerie Shute's interest and feedback was also valuable. I thank Rich Walker and Janice Hereford for their technical support.

I. INTRODUCTION:

Proficiency in graph reading skill is necessary for the successful implementation of many types of tasks, including flight engineering. Research dealing with the question of graph reading, or graph interpretation, has focused on perception, comprehension, or graphic design. To date research on graphs has not explored the more complex relationships between determinants of cognitive processing and graph reading skill.

The present study concerns the identification of some of the sources of individual differences in graph reading skill. A major question that arises in this effort involves which psychological constructs are needed to predict proficient graph reading skill.

The Learning Abilities Measurement Program (LAMP) of the Air Force's Human Resources Laboratory (AFHRL) at Brooks Air Force Base is especially concerned with the development of techniques for assessing individuals' knowledge and skill levels. The summer assignment at the Manpower and Personnel Division enhanced my research interests in the cognitive psychological constructs of graph reading skill.

II. OBJECTIVES OF THE RESEARCH EFFORT:

The goal of this research is to investigate graph reading skill by examining the associated underlying cognitive abilities. Specifically, do the sources of prior specific knowledge, working memory, and general knowledge correlate with graph reading proficiency? Further, which of these cognitive determinants best predicts graph reading skill proficiency?

The general theoretical framework guiding this study (Anderson, 1983) suggests that declarative knowledge and procedural knowledge influence the ability to do a skill in any domain. The Kyllonen and Alluisi (1987) model proposes that the way in which individuals process information is governed by five different sources, (a) working memory, (b) declarative knowledge, (c) procedural knowledge, (d) environment, and (e) cognitive processes.

Using this framework, two explanations for graph reading skill proficiency can be proposed. One is that graph reading is primarily determined by prior specific knowledge of graphs. The other explanation is that working memory is the primary determinant of proficient graph reading skill.

Data collection consisted of a battery of ability tests, and an instructional and testing session concerned with graph

reading skill. The abilities section includes (a) three measures of specific prior knowledge of graphs, (b) three measures of general world knowledge, and (c) three measures of working memory.

The general learning section consists of six measures of graph reading skill, including both declarative and procedural phases of learning. The instruction started with basic graph reading terminology and components, then advanced to inferential graph reading skills, including calculating displacement and slope.

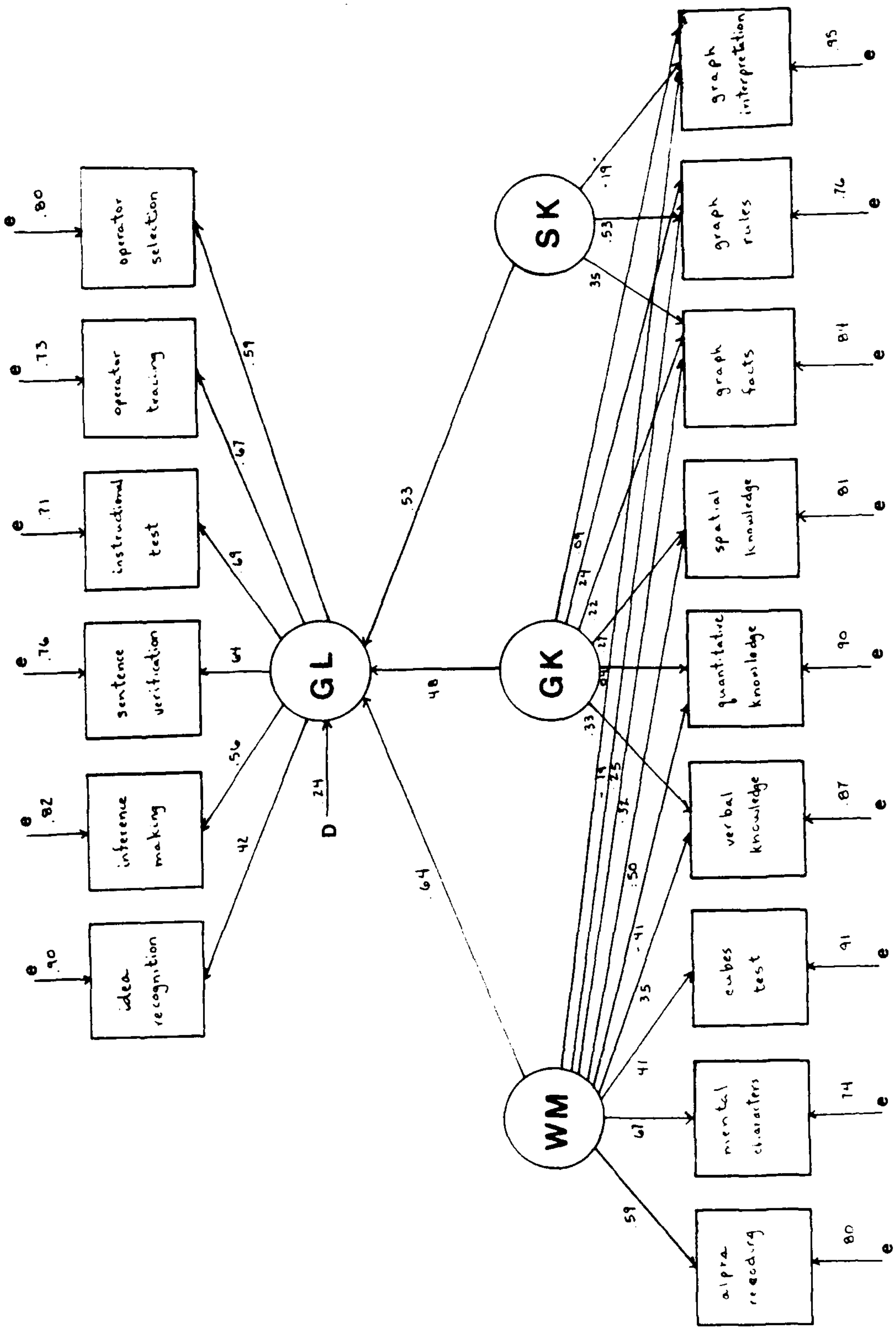
The entire test battery was administered to 330 military recruits at Lackland Air Force Base (LAFB), Texas. Subjects were in their eleventh day of basic training. All test materials were computer administered.

III.

a. A hierarchical path-analytic model was developed and tested for the data. The model was based on suggestions made by Gustafsson (1989), with further clarifications by Kyllonen (1990). The model, shown in Figure 1, uses standard path analysis notations. In the model, Working Memory (WM) is a determinant of performance in all of the nine cognitive tests. General Knowledge (GK) is a determinant in tests of general knowledge, as well as tests

FIGURE 1

Path diagram of the model for the data with standardized parameter estimates from the maximum likelihood solution. (WM = Working Memory; GK = General Knowledge; SK = Specific Knowledge; GL = General Learning; e = errors in variables; D = disturbance in factors.)


GL
GK
SK
WM
D
idea recognition
inference making
sentence verification
instructional test
operator tracing
operator selection
graph interpretation
graph rules
graph facts
spatial knowledge
quantitative knowledge
verbal knowledge
cubes test
mental characters

of prior Specific Knowledge (SK). In conformity to hierarchical specification, WM, GK, and SK are orthogonal to one another. The learning task is modeled using one factor, General Learning (GL).

b. The data fitted the model well, by Bentler and Bonnett's (1980) non-normed fit-index (NNFI = .978), and by a chi-square test ($x2[77] = 88.5, p = .174$). The primary finding was that the Working Memory factor played the greatest role in determining success in graph reading proficiency. All of the cognitive abilities tests loaded significantly on the Working Memory factor. The best indicators in the General Learning portion of the model were the procedural learning measures.

A rational argument on the side of individual differences analysis is that if a person has a larger working memory capacity then they should do better on graph reading tasks. Graph reading should be easier for a person who has a larger working memory capacity because they have an increased ability to hold information they are currently working on; enough so that correct decisions can be made about the material at hand.

Another rational is that if a person has more knowledge of graph reading facts and rules (specific prior knowledge), then they should do better on a graph reading task. This

means that graph reading should be easier for those who have a built-up knowledge about graphs, and this would be reflected in better performance on graph reading exercises.

IV. RECOMMENDATIONS:

a. From the results of this study it appears that working memory, general world knowledge, and specific prior knowledge of graphs each play a significant role in the general learning of how to read graphs. Working memory plays a greater role than prior specific knowledge. Procedural and declarative learning were not separable factors in this study. Only one factor, General Learning, was delineated in the measurement portion of the model.

This study was designed primarily to determine if a general cognitive theoretical model would fit the data, and if so, which factors are the primary contributors to graph reading skill. Similar models using the hierarchical modeling approach can be designed for other types of skills to observe the relationships among the cognitive determinants.

b. Based on the results of this study, it can not be concluded what type of working memory or specific prior knowledge predicts graph reading skill the best. A fruitful follow-on research to this study would be one in which spatial and verbal working memory were separate factors.

Specific prior knowledge could similarly be divided into separate prior declarative knowledge and prior procedural knowledge factors.

c. Another suggestion for further research would be within the aptitude-treatment-interaction paradigm. Such a study could track a student's progress through a series of learning tasks over a span of time, rather than relying on information obtained in one setting. Different graph reading modules could be designed to test for student aptitude, and/or learning style interactions.

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FINAL REPORT

SURVIVAL ANALYSIS: A TRAINING DECISION APPLICATION

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Date:	17 Aug 1990
Contract No:	F49620-88-C-0053

Same Report as
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(Report # 142)

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FINAL REPORT

PREDICTING THE IMPACT OF AUTOMATION ON PERFORMANCE AND WORKLOAD IN C^2 SYSTEMS

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FINAL REPORT

Peripheral vs. Foveal Contour Processing in Humans

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FINAL REPORT

Development of Groundwater Modeling in the Air Force Installation Restoration Program

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Date:	30 Sep 90
Contract No.:	F49620-88-C-0053

Development of Groundwater Modeling

in the Air Force

Installation Restoration Program

by

Andrew R. Bonas

ABSTRACT

Although not exact, contaminant transport and fate models have become more complex and reliable in the last decade. Use of these models could provide the Air Force Installation Restoration Program with a reliable and cost-effective tool for evaluating different remediation schemes, locating sources and determining risks. To this end, a list of modeling parameters that would need to be collected in the field was compiled. Also, a computer data base of parameters that have been listed in the literature was created to aid modeling in the absence of field data. Research was also conducted on tetrachloroethylene to determine how it could best be modeled. Eventually a computerized decision tree could be developed to enhance and facilitate the entire modeling process.

Acknowledgements

I would like to thank the Air Force Occupational and Environmental Health Office and especially the Installation Restoration Program for sponsorship of this research. I also appreciate Universal Energy System's help in coordinating all the administrative aspects of this program.

There were several people at Brooks Air Force Base who not only made our work easier by their support but also made it more enjoyable. Without Colonel Warren Hull, Dr. John Yu, Captain Logan Van Leigh, Captain Mike Stock and Captain John Irving we could not have accomplished what we did.

I. INTRODUCTION

Nature is an extremely complex organism that can seem completely unpredictable. In order to better understand its mysteries man has learned to peel away the layers and look only at a small part of it at a time; to literally study one small section. With the advent of the personal computer, man has been able to take what he knows about that one small section and piece it together with numerous other sections in order to better predict nature's behavior. It is this concept that lies behind the idea of computer modeling.

Computer modeling of groundwater has been in practice for several decades. It was not until the development of the Method of Characteristics model, written by Konikow and Bredehoeft, however, that it became an accepted tool for predicting the transport of contaminants. Even today, though, groundwater modeling is not always received with open arms. Some of this skepticism is well grounded; the most complex models still require some basic assumptions about the area being modelled. But some of this skepticism is also based on the fear of the unknown workings of the models and the disappointment when they do not produce an exact answer.

Modelling can, however, be used as an effective tool not only to predict future contamination, but also to determine sources of contamination and evaluate different remediation schemes. The

use of computer models can lead to a more efficient and cost effective Installation Restoration Program (IRP) in the United States Air Force.

II. OBJECTIVES OF THE RESEARCH EFFORT

Upon arrival at Brooks Air Force Base in San Antonio there were several objectives which my supervising professor, Dr. Medina, and myself hoped to accomplish in our ten weeks. Among these were the following:

i.) An evaluation of the list of parameters currently being captured by the Installation Restoration Program Information Management System (IRPIMS). In order to successfully model a site, some parameters that would not normally be gathered are necessary. A list of these parameters could be included in Air Force statements of work for other data collection.

ii.) A compilation of a computerized data base of reported literature values for various modeling parameters. When these parameters have not been collected in the field because a quick, rough model is needed or cost prevents their collection, this data base can provide numbers that are more reliable than educated guesses.

iii.) A series of seminars on the theory behind surface and ground water models. A greater understanding of the models can help remove some of the mystery behind them and reveal some of their limitations.

iv.) A literature research into how models can and have been used successfully in the real world.

v.) The possibility of the development of a

computerized decision tree for choosing appropriate models for various situations.

III.

i.) An evaluation of the list of parameters currently being captured by IRPIMS revealed that many parameters necessary for modeling are not collected. These parameters include effective porosity, transmissivity and/or hydraulic conductivity, total organic carbon, and others. A list was thus compiled so that it could be included in Air Force statements of work for sites where modeling was to be done.

ii.) Using PC-File and data from several Nuclear Regulatory studies a data base of modeling parameters was compiled. Each record in the data base included headings for the general parameter measured, the type and sub-type of the rock for which it was determined, the authors of the study, and the location of the tests. By using PC-File, the data base is capable of being searched by any one of the above mentioned headings, providing easy access to a large amount of literature data.

iii.) During our stay at Brooks Air Force Base Dr. Medina presented two seminars, one on surface water modeling and one on groundwater modeling. Both of these seminars concentrated on giving an overview of the theory behind models. It was hoped that this background knowledge would help remove some of the mystery behind models and give some insight into their limitations.

iv.) While at Brooks we discovered that one of the most common contaminants that faces the Installation Restoration Program is the chemical tetrachloroethylene or PCE. Because of its frequency of occurrence, we decided to research some of the more recent studies that have been conducted on it to determine the feasibility of modeling it given appropriate aquifer conditions. The research included determination of its general toxicity background, sorptive properties, ability to biodegrade into more dangerous chemicals such as trichloroethylene and vinyl chloride, and models that have been created to simulate these properties. This research culminated in a report that will allow it to be modeled more easily and accurately in the future.

v.) The ten week time frame for our work at Brooks did not enable us to develop any type of computerized decision tree for modeling. Our time there did, however, help us to determine how such a system could best serve the Air Force's needs.

IV. RECOMMENDATIONS

Although we were able to accomplish a great deal, there is much more work that could be done. One of the most obvious and important is to actually model a site, especially a PCE contaminated site. Also, follow up work on what was achieved would greatly enhance its value. For instance, the computerized data base of modeling parameters contains over one thousand records but represents only a small fraction of what has been reported in the literature. Furthermore, the development of a computerized decision tree for evaluating alternatives could be an invaluable, cost-effective tool for the Air Force.

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FINAL REPORT

EFFECTS OF REPEATED DAYS OF LIGHT WORK AT MODERATE TEMPERATURES IN THE PROTECTIVE CLOTHING

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USAF Researcher:	Stefan H. Constable, Ph.D.

Date:	25 July 90
Contract No:	F49620-88-C-0053

EFFECTS OF REPEATED DAYS OF LIGHT WORK AT MODERATE TEMPERATURES IN THE PROTECTIVE CLOTHING

by

Janet Solomon
Janis Beaird
James Kime

ABSTRACT

Six subjects participated in a study investigating the effects of repeated days of light work at moderate temperatures in the Chemical Defense Ensemble (CDE). This study was designed to evaluate individual physiological responses to identical workload and environmental conditions to determine if mean data is appropriate for estimating work capabilities while wearing the CDE. Each subject donned the CDE and exercised on a cycle ergometer in a heated room (29°C) at a work rate of 38 W until reaching a rectal temperature (Tre) of 38.3°C. The subjects then ended this work cycle and rested in a cool room (21°C) to a Tre of 38°C. The exercise was repeated to a Tre of 38.3°C, and subjects recovered as before. The work/rest sequence was repeated for four hours on four consecutive days. The data indicates that large differences exist in individual performance while wearing the CDE. Further research is needed to investigate the possibility of creating individual performance prediction equations using easily obtained field data.

ACKNOWLEDGEMENTS

We wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of these graduate summer fellows. Universal Energy Systems also deserves acknowledgement for handling all administrative aspects of this program smoothly and efficiently.

We found this research experience to be truly rewarding. It allowed us the opportunity to broaden our knowledge in the field of thermal physiology. Our research was conducted in the School of Aerospace Medicine under the guidance and support of Dr. Stefan Constable. The assistance of Sue Bomalaski was invaluable in setting up the research facility. We would also like to thank Dr. Mel Antunano and Roshall Anderson for their assistance with the collection of data. Through the support and encouragement of these individuals and our major professor, Dr. Phillip A. Bishop, these research fellows have had a very enriching experience.

I. INTRODUCTION:

It is well established that the use of protective clothing in moderate to hot environments attenuates work capacity (Atterbom and Mossman, 1978; Smolander et al., 1984; Goldman, 1985; Bishop et al., 1988; Constable et al., 1988; White et al., 1989; Nunneley, 1988, 1989). In many military and industrial situations where the use of protective clothing is required, repeated days of work are often necessary. Many studies have investigated the physiological effects due to wear of the Chemical Defense Ensemble (CDE) at different work loads and temperatures (e.g. Bishop et al., 1988, Constable et al., 1988). However, previous research on effects of protective clothing have deliberately been designed to avoid repeated exposures to work in the clothing to avoid any residual effects. Because of this little is known about the physiological consequences of repeated days of work in protective clothing or the individual differences in work capacity while wearing the CDE. In attempting to make predictions about work performance, some investigators have created equations which assume certain constants; expecting individuals of varying fitness or acclimatization to perform equal amounts of work in the CDE. An alternative to this traditional approach to modelling physiological responses is to predict an individual's response based upon previous data recorded in a brief exposure to a similar environment. This approach has been described by Bishop (1990), and is termed "Empirical Prediction" (EP).

II. OBJECTIVES:

It is of value to understand the physiological stress placed on the body due to wearing the CDE. Several researchers have established guides that estimate the amount of work that can be expected from a person donning the CDE at different workloads in different

temperatures. These guides are based on group mean data and do not consider physiological differences in human performance. In addition, little is known about how the cumulative physiological effects of repeated days of work in the CDE alter work capacity. The purpose of the present research was to examine the effects of four consecutive days of exposure to light work in protective clothing in a moderate environment and to observe whether a significant amount of individual variability in physiological measures, such as Tre change during work and rest, existed between subjects. Our assignment as participants in the 1990 Summer Graduate Research Program was to collect and analyze initial data concerning the physiological consequences of repeated days of light work in a moderate environment while wearing the CDE. This preliminary research was also designed to determine if further investigation would be necessary to create an empirically based prediction equation for individual work capacity while wearing protective clothing.

III. METHODS:

Subjects for this study were six volunteers from the Brooks AFB military and civilian community (five male, one female). Two of the authors served as subjects. Subjects provided informed consent in accordance with USAF requirements. Subjects were heterogeneous in size, physical fitness, and acclimation state.

After completing a survey of their athletic activity, recreational activity, and exposure to hot environments, subjects were weighed nude. They then were instrumented with thigh, calf, chest and forearm skin thermistors, a heartrate monitor (Exersentry), and rectal thermistor located 10 cm beyond the anal sphincter. Subjects then donned a 50% cotton/50% polyester undershirt and shorts, standard military fatigue pants and shirt (50% cotton/50% polyester), chemical/biological overgarment (carbon impregnated foam pants

and jacket), MCU-2P gas mask, butyl rubber hood, and butyl gloves with cotton liners. Athletic shoes were worn for comfort and safety. This chemical defense ensemble (CDE) configuration has an insulative value of 2.3 clo, (1 clo = 5.55 $Kcal/m^2/^oC$) and an impermeability index of 0.2.

After being weighed in the complete CDE, the subjects entered a heated room (29°C) where they exercised by riding a cycle ergometer at a work rate of 38 W (225 kpm) until rectal temperature (Tre) reached 38.3°C. Subjects were then moved to an air conditioned room (21°C) where they cooled down to 38.0°C. This was intended to simulate employment of a microenvironmental cooling system or other cooling protocol. Subjects then reentered the heated room and repeated exercise to 38.3°C, recovering as before. This work/rest sequence was repeated for four hours. Subjects were then reweighed both nude and clothed for determination of sweat production and evaporation. Subjects were permitted to drink ad libitum, and volumes were recorded.

Mean skin temperature was calculated according to Burton (1935) and surface area according to Dubois and Dubois (1916).

IV. RECOMMENDATIONS:

a. Numerous studies have shown that when wearing protective clothing, human physiological work capacity is reduced substantially (Atterboom and Mossman, 1978; Smolander et al., 1984; Goldman, 1985; Bishop et al., 1988; White et al., 1989; Nunneley, 1988, 1989). Researchers have previously developed mathematical models to predict aspects of the physiological response to a given set of work and environmental conditions while wearing the CDE (Givoni and Goldman, 1968; Wissler, 1986; Pandolf et al., 1986). These models assume certain constants for all individuals. For example single body specific heat, single mechanical efficiency, initial rectal temperature

(Tre), tissue conductance, and clothing fit are weighted equally for all subjects. Therefore, individual human physiological variability is ignored. However the fact that individuals differ in body composition, morphology, physical fitness, motivation, and efficiency is obvious and inter-subject variability is well documented (e.g. Mar'yanovich et al., 1984; Vogt et al., 1983; Krajewski et al., 1979; Bell and Walters, 1964).

The present study, though limited by a small subject pool, indicates great variability among subjects while working at a constant load in a similar environment. Figure 1 shows that individuals baseline Tre varies both among and within subjects from day to day. This could be due to a variety of factors including cumulative stress or acclimatization. In response to the task of work to a Tre of 38.3°C followed by rest to a Tre of 38.0°C, work to rest ratios varied greatly (Figure 3).

As mentioned previously, subjects began the first cycle of this experiment with a range of initial Tre's. As a result, there were various deltas in Tre during the first work cycle to 38.3°C (Figure 2). Following the first work cycle, all subjects cooled to a Tre of 38.0°C before beginning work again and all subjects ended work at 38.3°C for all subsequent work/rest cycles. If we could assume that all humans begin work in similar physiological states and progress in a similar manner while performing the same work in the same environment, performance could be predicted for all individuals using mathematical equations that assume certain constants for all subjects. If this were the case, individual performance for the entire experiment could have been predicted following the first work/rest cycle. However, in this particular study, variability among subject performance was quite large and if the present methods of predicting performance in protective clothing using mean values had been applied, heat injury could have been a potential problem. For example, one person may perform at or above the work requirements of the group mean predictions while another person

may perform severely below the work requirements of the group mean predictions and therefore be in danger.

This study indicates that although you might expect subjects to perform similarly under the same conditions, in reality individual performance covers a wide range from the mean in most instances. For example, subject 3 had an average work-rest cycle ratio of 6:1 on day 3 of this experiment, while the average for all subjects was 2.5:1 (Figure 3). This subject was extremely fatigued and refused to continue work on several occasions. This is an example of the problems which can arise when expecting all individuals to respond similarly to a protocol designed for a group mean.

An alternative to traditional modeling of physiological responses is to predict an individual's response based upon previous data recorded in a brief exposure to a similar environment. This approach has been described by Bishop (1990), and termed "Empirical Prediction" (EP). The refinement of this approach would allow for more accurate guidance in the use of personnel exposed to heat stress conditions; for example, when wearing the CDE and working in warm or hot conditions. It would also aid in reducing the risk of heat stress which is inherit in current predictive equations. The present investigation adds evidence indicating a need for further perfection of the empirical prediction equation proposed by Dr. Bishop.

b. It is important to understand how individuals will respond to certain work loads and environmental conditions while wearing the CDE. As stated earlier, there have been numerous studies which have investigated these variables. However, these studies were designed to avoid cumulative stress. Subjects were asked to work on one occasion and were not allowed to participate again in the experiment for several days. Thus, there is no documentation of how individuals respond to repeated days of work in the CDE.

When looking at figures 1 - 6 , it is evident that each subject differs in their response to work from day to day. Subjects two and six

were acclimated to work in hot environment, but were not similar in repeated day responses. The other four subjects also differed in their day to day responses.

Further investigation is needed to understand these cumulative effects of work since it is unlikely that in an actual working environment a person could work one day and rest seven or more. Therefore, it is necessary to try to determine how individuals will respond in protective clothing when asked to work for consecutive days.

When looking at this preliminary data, there are no obvious trends in physiological responses from subject to subject or day to day. Therefore, we recommend that future investigation concentrate on the development of prediction equations that can estimate individual work potential. Also, efforts should be made toward understanding how cumulative days in the CDE can affect individuals performance.

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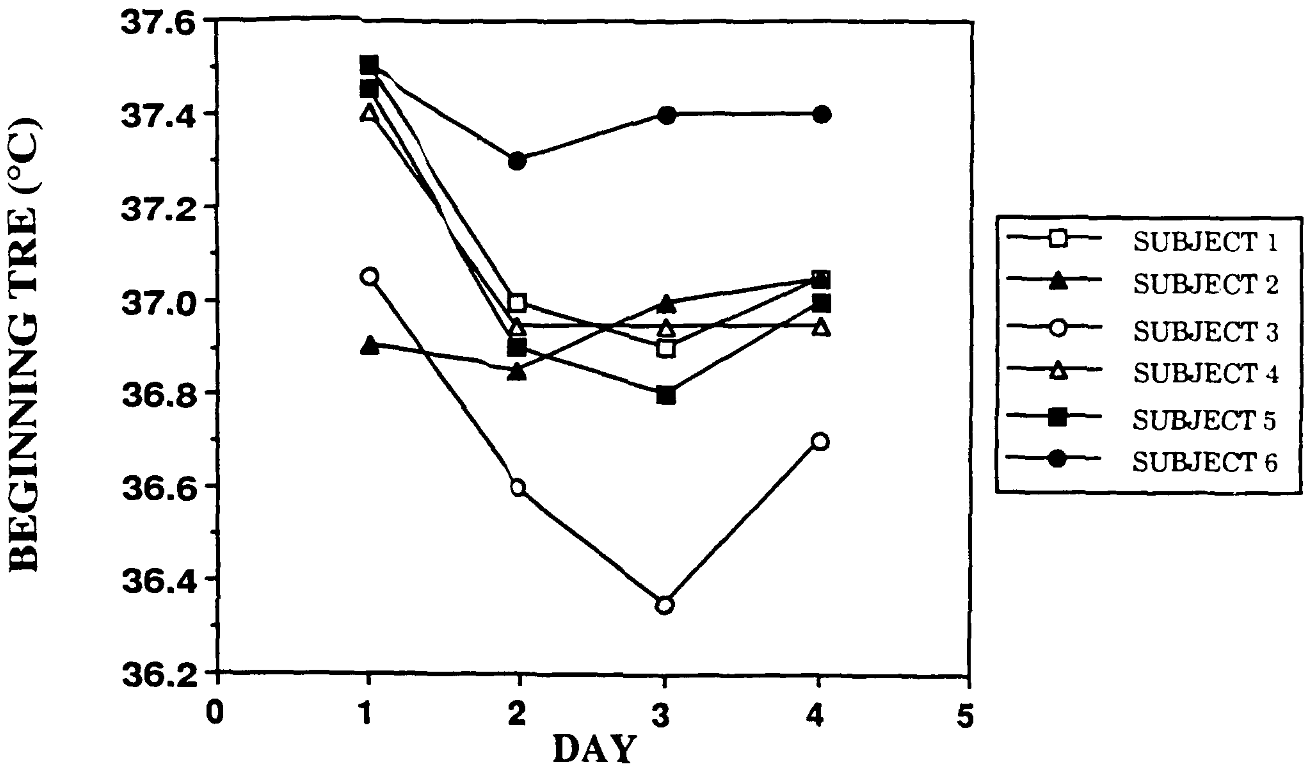


Figure 1. Beginning Tre's for each subject on all days.

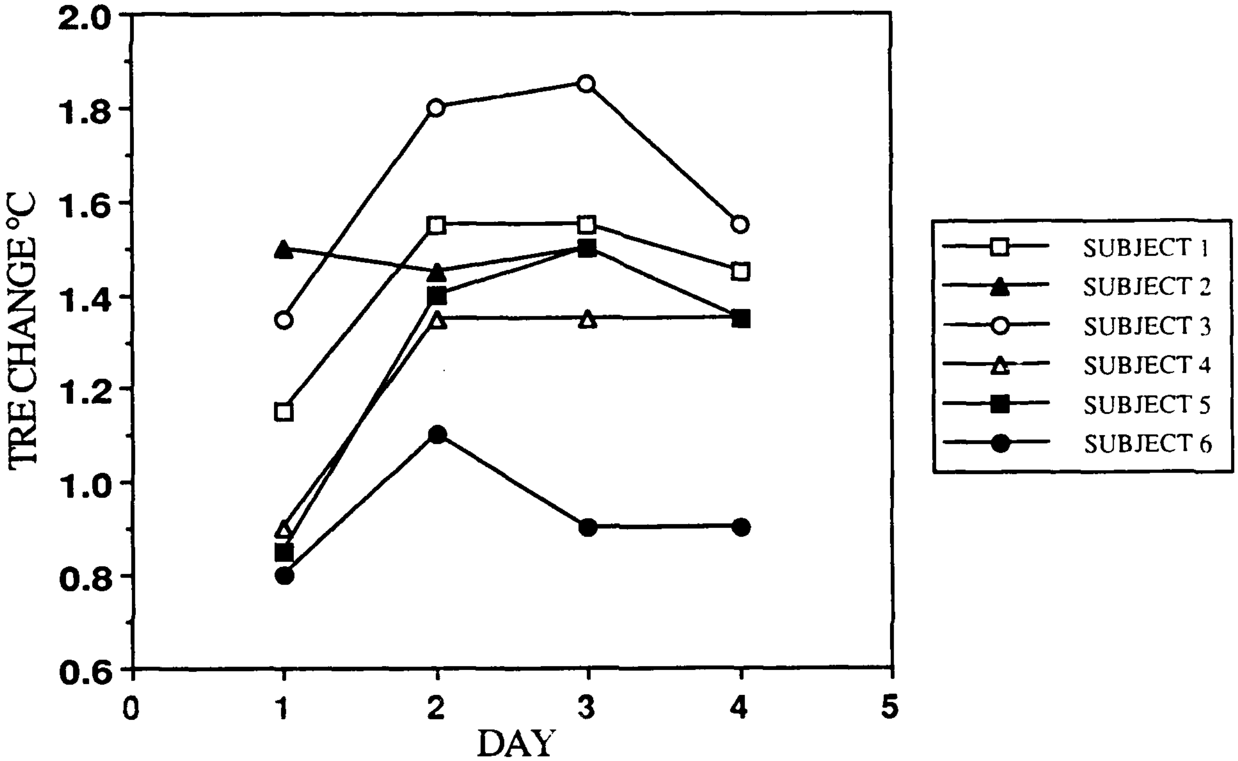
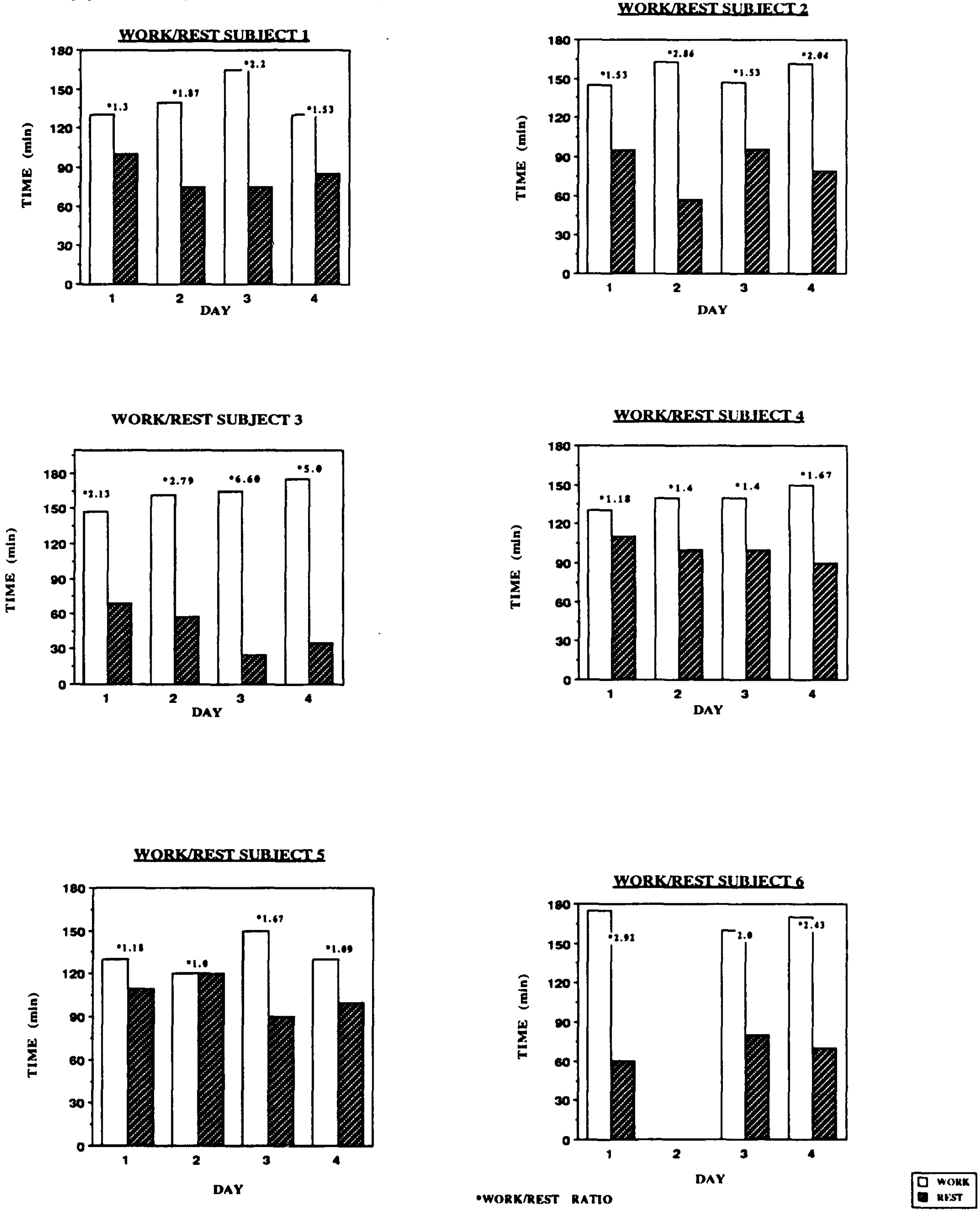


Figure 2. First work cycle, change in Tre for each subject on all four days.

3. Work/rest graphs for each subject on four consecutive work days.



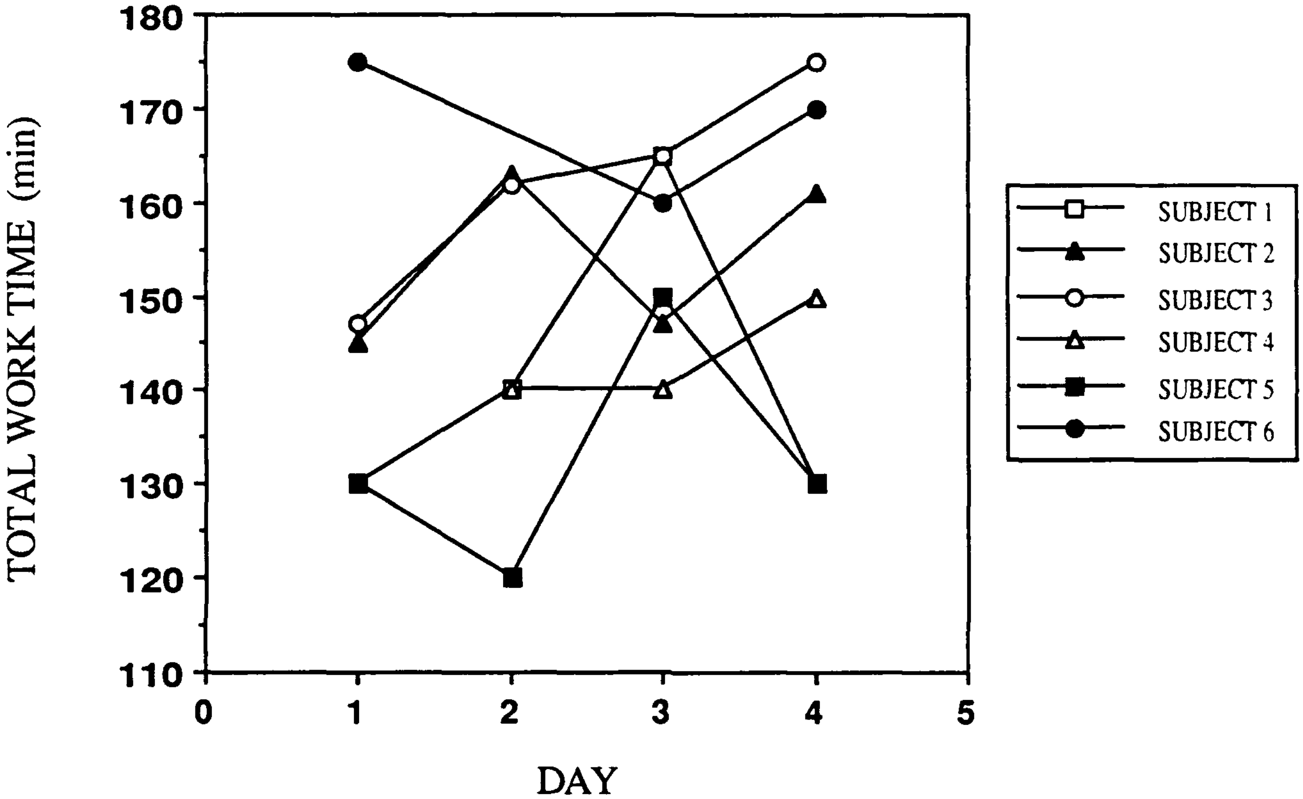


Figure 4. Total work time for each subject on each work day.

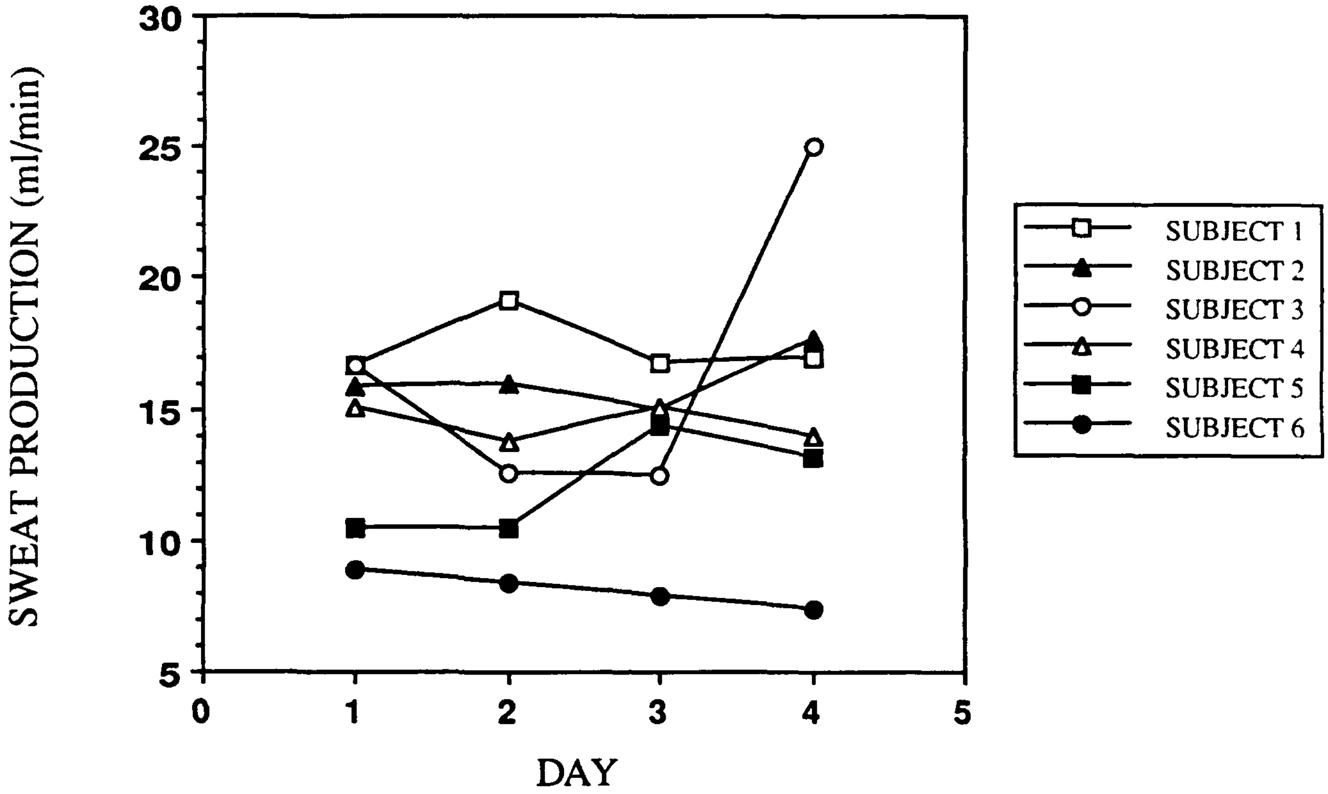


Figure 5. Sweat production for each subject by day

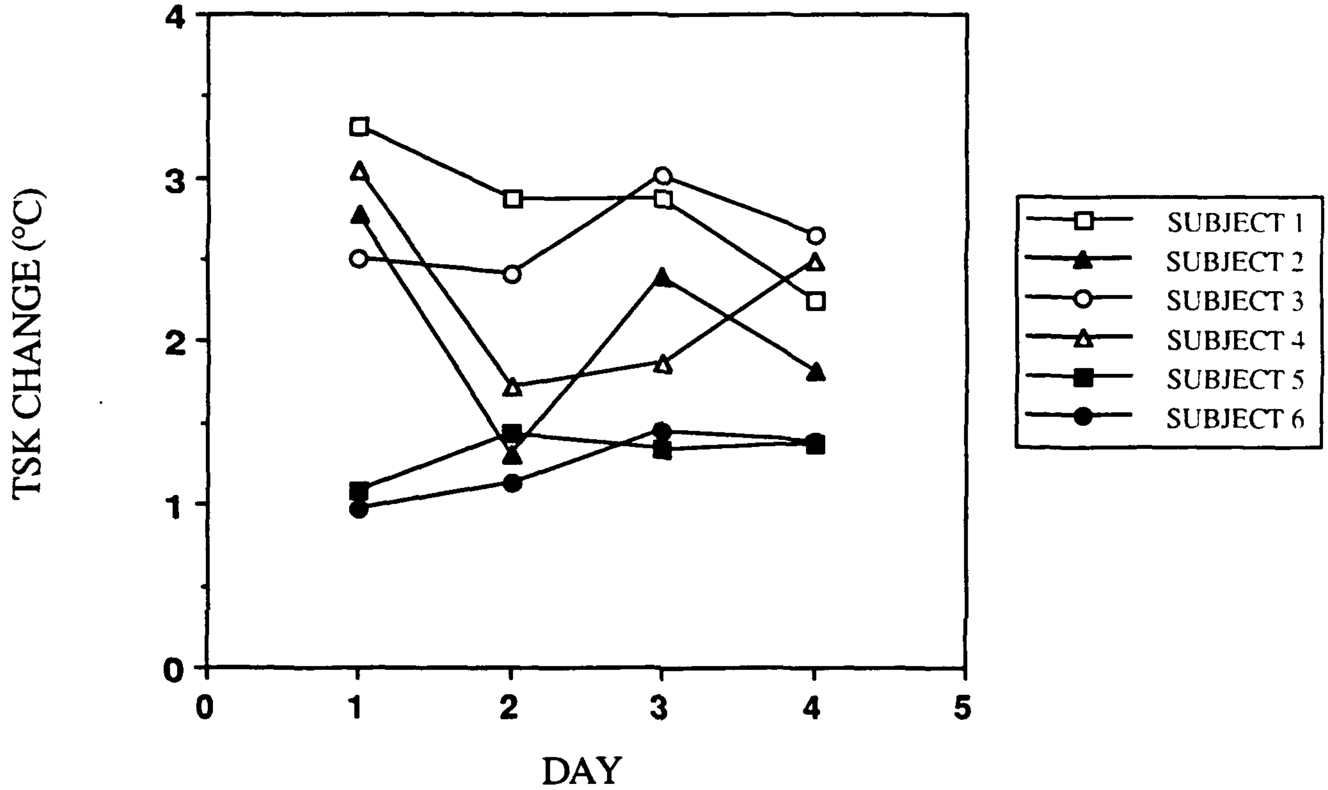


Figure 6. Mean Tsk change during work cycle for each subject by day.

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FINAL REPORT

Predisposition of Mammalian Cell Cultures Treated with Aflatoxin B1 to Potential Radiation Effects.

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Date: 24 Aug 90

Contract No: F49620-88-C-0053

Same Report as
Prof. Paul Lemke
(Report # 157)

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Universal Energy Systems, Inc.

FINAL REPORT

Organizational Learning and Aircrew Performance

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Organizational Learning and Aircrew Performance

by

Thomas J. Broersma

ABSTRACT

Organizational learning theory and action science heuristics were used in this interpretive study of Airborne Warning and Control System (AWACS) aircrew performance. The data for this study are drawn from an unclassified research study currently being conducted at Brooks AFB. The research simulation uses six empirically derived, unclassified, air defense AWACS scenarios. The actions taken and communications of one team were transcribed and ten critical incidents were interpreted. The study found that the organizational learning patterns of the team were problematic but two examples of "double-loop" learning were identified. This suggests that the team was beginning to correct the flaws in its pattern of organizational learning. Further research will compare the team's organizational learning patterns with other high workload scenarios in which the team achieved higher levels of performance. The final stage of research will be to compare the organizational learning patterns of all twelve teams which participated in this simulation experiment.

Acknowledgements

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy systems must also be thanked for assistance and direction in the administration of the program.

In undertaking this research project, I must recognize and give heartfelt thanks to those who gave time to assist me in the collection of the data and in its interpretation. Dr. Douglas Eddy provided me with encouragement and direction. Matthew Dalyrmple gave unstintingly of his precious time to answer numerous questions. Dr. Samuel Schiflett assisted in the overall project direction.

Dr. Karen Watkins of the University of Texas has given me many hours of her time and has unselfishly shared her knowledge of organizational learning and action science. Without her encouragement and direction this project would neither have been conceived nor completed.

I. INTRODUCTION:

This interpretive study is an inquiry into the nature of organizational learning. Organizations when viewed from a theory of action perspective are social entities which engage in continuous processes of problem solving which Argyris and Schon (1978) have termed organizational learning. The general question of interest in this study is how organizations learn to perform at high levels of efficiency and effectiveness in the midst of a complex social and political environment.

II. OBJECTIVE OF THE RESEARCH EFFORT:

The objective of this study was to analyze the learning patterns of an aircrew in an attempt to explain the level of performance achieved by them. While the simulated organization of this research study involved many actors, the study focused on the organizational learning patterns of a group of three weapons directors (WDs) and a senior director (SD) in an environment simulating a highly controlled air defense setting. Throughout the experiment, the performance goals the group is seeking to achieve remain clearly defined and unquestioned. Thus, this study does not involve organizational learning oriented toward the revision or modification of performance goals.

III. RESEARCH METHODOLOGY:

The data for this study are drawn from an unclassified research study currently being conducted by the U.S. Air Force at Brooks AFB. The research simulation uses six empirically derived, unclassified, air defense Airborne Warning and Control System (AWACS) scenarios. A performance measurement hierarchy was established for the experiment. Overall Mission Effectiveness measures are derived directly from the specific objectives of the mission. System/Team Performance measures reflect the degree to which the total system successfully accomplished the tasks essential to mission success. Human Performance measures are designed to reflect the quality of the individual behaviors required of the weapons director. These measures are expressed primarily in terms of latencies and errors. Performance Capability measures consist of a large group of potential human state and ability metrics that combine to determine overt performance. In this hierarchy, measures at each of the levels differ in their sensitivity, generalizability, and practical interpretability.

At the Mission Effectiveness level, the viewpoint of the Air Defense Commander (ADC) was taken. The ADC is interested in two basic questions. Did the subjects win the war? What was the cost? In articulating specific questions, a model of behavior was assumed:

Detect ->Identify ->Intercept ->Destroy = Assets Protected

Figure 1

Asset protection results from intercepting and destroying enemy aircraft, which is based on identifying and detecting them in a sequential process. Therefore, the ADC is seeking answers to questions such as: the number of strike completions, the total assets lost by category, kill ratios, percent loss of assets, enemy tactics used, an interpretation of the week's war, the position of destroyed hostiles using time and distance, the position of targets when first detected, the total number of misindentifications, friendly losses by friendly fire, and losses by fuel out. A composite score was calculated based on the wieghted scores of each team's performance on the above measures.

The following cognitive map, based on Action Science (Argyris, Putnam & Smith, 1985), was assumed as the basis of this interpretive study:

Initial Conditions	->	Framing Assumptions	->	Behavioral Strategies	->	Consequences: Match Mismatch (Error)

Figure 2

The initial conditions identify the environmental conditions under which the team is operating. These conditions include the conditions of war and the level of enemy and friendly activity. Related to the model of behavior shown above, this is the level of detection. Framing assumptions govern behavioral strategies. For example, if an aircraft is detected and determined to be hostile, the framing assumption is defense. The behavioral strategy which follows this assumption is to intercept the enemy and under conditions of war destroy the aircraft if possible. Consequences are either a match, a mismatch (error) or both. A match occurs when the outcome is completed as planned. A mismatch (error) occurs when the outcome is not completed as planned. When error occurs, learning can also occur.

When repeated attempts to correct an error by modifying behavioral strategies results in continued error, the organization is confronted with the need to revise its framing assumptions. The modification of behaviors is termed single-loop learning. For example, learning to detect and identify enemy aircraft more effectively would be single-loop learning. By contrast, the alteration of framing assumptions is termed double-loop learning. For example, if weapons directors are framing their responsibilities as autonomous and discover that this relationship of autonomy is leading to error, they can choose to engage in double loop learning and revise this assumption. If they reframe their relationship as interdependent and create behavioral strategies to coordinate their activities with the result that errors are reduced or eliminated, this would be successful double-loop learning.

In this study a period of approximately one hour was chosen during which the weapons director team committed a large number of errors and consequently the team level performance for that scenario was extremely poor. The rationale for selecting this period followed from the theory of organizational learning: learning results from the detection and correction of error. Based on the critical action research model described by Carr and Kemmis (1986), organizational learning is viewed in this study as a self-reflective spiral of four phases or "moments" is illustrated in the following figure:

	Practice	Discourse
Reconstruction	1. Observation	2. Reflective Analysis
Construction	4. Action	3. Planning

Figure 3

Based on this model of organizational learning, the primary research question for this study is: Does the organizational learning model (observation, reflective analysis, planning, action) describe the organizational learning patterns of the aircrews? Specific research questions inquire into each phase of the model.

The observation phase is the reconstruction of action by the aircrew. Reconstruction can be accurate or inaccurate. Hence, the first phase of the research is to analyze the aircrew's reconstruction of the action. The research question of interest in this phase is: Does the aircrew detect the error identified by the research team? A related question of interest in this phase is the accuracy with which the aircrews reconstruct the actions which produced the error.

The reflective analysis phase is the aircrews' discursive reflection on and analysis of the cause of the error. In action science, "Model I" and "Model II" discourse is distinguished. Model I discourse includes making unillustrated attributions and evaluations, advocating courses of action in ways that discourage inquiry, treating one's own views as obviously correct, making covert attributions, evaluations, and face-saving moves such as leaving potentially embarrassing facts unstated. Model II discourse, in contrast, combines advocacy and inquiry and is characterized by attributions and evaluations which are illustrated with relatively directly observable data, and the surfacing of conflicting views in order to facilitate public testing of them. Hence the question of interest regarding this phase of the action research is to confirm or disconfirm this finding: What model of discourse do the aircrews use in critically reflecting on the error? A second question of interest in this phase is the accuracy with which the aircrews analyze the cause of the error.

In the planning phase the aircrews attempt to construct a new practice. This phase of the study focused on how the aircrews create new strategies. The research question of interest in this phase is: How do the aircrews create new strategies to correct the error? A second question focuses on the effectiveness of these strategies.

The action phase is the construction of practice. The research in this phase is focused on the aircrews' enactment of its planned actions. The research question of interest is: Does the aircrew enact the plan it has created? A second question asks whether the plan was successful in overcoming the error.

IV. ANALYSIS OF CRITICAL INCIDENTS:

a. This case study is drawn from the aircrew's second exposure to an equivalent high work load scenario for Team 2. During this scenario, the second of three high work load scenarios, Team 2 commits multiple errors with the consequence that its composite performance rating is -71.8. (The composite score includes several critical variables weighted in importance. The more negative the score, the worse the performance is rated.) The case captures Team 2 during the final hour of this scenario. The approach to the analysis of this case is as follows: (1) critical incidents from the scenario are selected where an observable error has been committed by Team 2; (2) communications by Team 2 at the time of the critical incident were transcribed; (3) the communications were analyzed using the organizational learning model and action science heuristics.

b. Summary of Research Results.

Critical Incident 1. Both weapons directors act unilaterally. WD2 unilaterally announces that he is going "Bullseye" without asking for help or whether there might be another solution to the problem of overload. WD3 unilaterally agrees to maintain responsibility for the enemy without inquiring into other possible solutions. The apparent contradiction in the learning system exhibited in this incident is that both weapons directors share a theory-in-use that closes them off from effectively communicating with each other.

Critical Incident 2. In this incident what is problematic is that WD1 recognizes an error, but does not pursue the resolution of this error when he receives no satisfactory response to his question.

Critical Incident 3. What is problematic in this incident is the failure of inquiry and the closed communication pattern. With the failure to communicate correct information, the learning system is flawed and further errors will predictably be committed.

Critical Incident 4. WD2 defends his decision by advocating his position. SD seems to hold a negative evaluation of WD2 's decision but communicates the evaluation indirectly. WD2 seems to recognize SD's negative evaluation and defends his decision. The contradiction in the learning system is that because the communication is closed, the decision is not examined and a superior plan cannot be created.

Critical Incident 5. This incident is an illustration of single-loop learning. When the weapons directors discover that they have made an error, they go on to correct the error. The problem with this learning pattern is that they do not inquire into how the error occurred. As a result, they may repeat the error again since they do not know how it originally occurred.

Critical Incident 6. Single-loop learning is again illustrated in this incident. The outcome of this learning incident is the discovery of error and the immediate cause of the error. The reason WD3 failed to have the vital information regarding the activation of the SAM site remains unexplored and hence undiscovered.

Critical Incident 7. Another example of single-loop learning is illustrated here, resulting from the error of an unpaired enemy aircraft. When SD recommends that WD1 coordinate the response and "go through the lane" he is acting on the implicit assumption of shared responsibility. SD is unilaterally advocating his position of a structural solution to the problem of coordination. The unintended outcome of this action is that there is no double-loop learning, the WDs do not learn how to discover the error in their framing assumption.

Critical Incident 8. This is an example of double-loop learning. WD3 acknowledges that WD2 has a problem and inquires into the problem using Model II discourse.

Critical Incident 9. Another example of double-loop learning is exemplified in this incident. The WDs and SD hold different views of the identity of ME12. A test is constructed to determine the identity of ME12. This is double-loop learning because the WDs and the SD agree to test their different views rather than defend their own assumptions. Agreeing to test differing views is based on the assumption that the team shares responsibility for the correct identification of aircraft.

Critical Incident 10. Here is an example of illogical reasoning and flawed organizational learning. Because the previous enemy pretended to be friendly, the weapons director and pilot assume that 4231 must be an enemy since he is communicating as a friendly. The conclusion could be correct, but the reasoning is flawed. The team fails to construct a test which can distinguish an enemy from a friendly.

V. RECOMMENDATIONS:

a. This interpretive study used organizational learning and action science heuristics as a way to explain the performance of Team 2 during a one hour period of a high workload scenario. Using these heuristics, the study has shown that the learning patterns of Team 2 are problematic. It is the conclusion of this study that the primary contradiction in the learning pattern of Team 2 is its unilateral, individual level of learning, a closed communication pattern between the weapons directors. However, the study illustrates two incidents of double-loop learning which suggests that Team 2 is beginning to correct the flaws in its organizational learning, an hypothesis which can be tested in the next stage of the research project.

b. It is recommended that the next stage of the research investigate the learning patterns of Team 2 during all three high workload scenarios. Measures can be established to compare organizational learning patterns during each of the high workload scenarios. It is hypothesized that an organizational learning pattern of open communication will positively correlate with levels of team performance. The final stage of research can test this hypothesis by comparing the organizational learning patterns of all twelve teams which participated in this experiment.

c. These preliminary findings and the final results of this research should be of considerable interest to the United States Air Force. Problematic organizational learning patterns such as those shown in this case study can result in poor levels of team performance and under conditions of war can lead to unintended death. On a positive note, this team demonstrated the capacity for organizational learning, the correction of errors in the organization's learning system, a capacity which will be studied in greater depth in the next stage of this research project.

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FINAL REPORT

PCR Analysis of Ureaplasma urealyticum and Mycoplasma nominis

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Department and University: Biology Department, University of Scranton

Research Location: USAFSAM/EKLM, Brooks AFB TX 78235-5301

USAF Researcher: Ferne K. McCleskey

Date: 3 August 1990

Contract No: F49620-88-C-0053

Same Report as
Prof. Vito Delvecchio
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FINAL REPORT

The Effects of Propranolol on Thermoregulation During Radiofrequency Radiation-Induced Heating and The Examination of Host/Graft Integration in the Rat Hippocampus Using Multiple Site Optical Recording

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and

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by

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ABSTRACT

Multiple site optical recording of membrane potential allows the visualization of neuronal activity over a broad area simultaneously, utilizing a voltage sensitive dye which responds rapidly, and in a linear fashion, to changes in membrane potential by altering its absorbance. In the present study, optical recording was used to evaluate the integration of cortical and hippocampal tissue transplanted into the hippocampus of male rats approximately 2 years prior. 400um sagittal sections of living tissue were made using an oscillating tissue slicer. The tissue was kept alive by constantly bathing it in artificial cerebrospinal fluid oxygenated with 95% O_2/5% CO_2. Results from this experiment suggest that hippocampal tissue integrates better than cortical tissue grafted into the hippocampus. Secondly, grafts in ectopic locations integrate less well than those in the hippocampus.

The beta-adrenergic antagonist propranolol interferes with the thermoregulatory responses of anesthetized male rats exposed to 2.45 GHz radiofrequency radiation. Heart rate, blood pressure, respiratory rate and temperature at five locations were recorded during radiofrequency radiation exposure. Propranolol significantly decreases both the colonic temperature at death, and the time required to reach lethal temperature from 38.5°C, when administered in a dose of 10 mg/Kg body weight, intramuscularly.

I. INTRODUCTION:

The Radiation Sciences Division (RZP) at the United States Air Force School of Aerospace Medicine, Brooks Air Force Base, Texas, is composed of investigators in the fields of physiology and neuroscience. The research in these two fields is tied together by the common interest in the biological effects of radiofrequency radiation (RFR).

Exposure of animals or human beings to RFR results primarily in heating of the exposed tissue. However, due to the electromagnetic nature of radiofrequency waves, the pattern of heating can be much different than that caused by an increase in ambient temperature. Consequently, the physiological and neurochemical responses of an organism to RFR exposure are unique. It is therefore important to examine these responses to better understand the effect of RFR exposure on biological systems.

I hold a Bachelor of Science degree in Biological Sciences. My course of study focused on organismal biology, and my own interest was in mammalian physiology. As a graduate student, I am researching questions of neurobiology, particularly neurochemistry and neuroanatomy. Furthermore, I am strongly interested in the effects of ionizing and non-ionizing radiation of the neuroendocrine system. My long range objective is to conduct research in the field of Aerospace Medicine.

Consequently, I was chosen by the members of RZP to assist in research pertaining to physiology, neurochemistry and neuroanatomy. My knowledge of these fields of biological research is complimented by my ability to perform surgical techniques, including catheterization and stereotaxic surgery, as well as the isolation, sectioning and preparation of brain tissue for microscopic examination

II. OBJECTIVES OF THE RESEARCH EFFORT:

During my term of appointment at the School of Aerospace Medicine, I assisted with two ongoing projects. My responsibility in the first

project was to determine the effects of the beta- adrenergic receptor antagonist propranolol on the thermoregulatory responses of anesthetized rats exposed to 2.45-GHz RFR. Propranolol is commonly prescribed by physicians to manage a variety of cardiovascular conditions. It prevents peripheral vasodilation, and slows the intrinsic rhythm of contractility in the heart. My second task was to examine the hippocampi of rats that had received grafts of cortical or hippocampal tissue, using multiple site optical recording. The purpose was to observe neurophysiological function for indications of integration of host and graft tissue.

III.

PROJECT I. <u>The Effects of Propranolol on Thermoregulation During Radiofrequency Radiation Induced Heating</u>

a. I worked under the guidance of Dr. James Jauchem, Ph.D., and Dr. Melvin Frei, Ph.D. , measuring the physiological parameters of blood pressure, heart rate, respiratory rate and body temperature during a terminal exposure to RFR- induced heating. Further, I wanted to observe the effects propranolol had on these parameters in order to make an inference about the role of the beta-adrenergic system in thermoregulation.

b. All animals in this study were Sprague-Dawley male rats. Rats were anesthetized with Ketamine HCL, 150 mg/kg, intramuscularly. Additional doses were administered as required to maintain anesthesia throughout the entire experiment. I catheterized the left carotid artery in order to measure blood pressure. In the exposure chamber, the animal was placed on a plexiglass holder in the H orientation, so that the long axis of the animal was parallel to the magnetic field, and the left side of the animal was nearest the antenna (Frei et al. 1989). Respiration was measured with a pneumatic bulb transducer. Leads for an EKG were attached to the right forelimb, and both the right and left hindlimbs. Body temperature was measured at the colon, left and right sides (lateral,

midthorax, subcutaneous), the base of the tail and the right tympanic membrane. These methods are fully described by Frei, et. al., 1989.

c. Animals were exposed individually to far-field, 2.45-GHz, continuous-wave RFR. All exposures were conducted in an exposure chamber at the RFR facility at the School of Aerospace Medicine, Brooks AFB, Texas. Because individual animals have different baseline temperatures, each rat was exposed to a warm-up period, during which its colonic temperature was raised to 39.5°C. When this temperature was achieved, the radiation source was turned off, and 10mg/Kg body weight of propranolol were administered to the animal intraperitoneally. Control animals received an injection of saline in an equivalent volume. When the colonic temperature returned to 38.5°C, RFR exposure was commenced until death occurred. Survival times, along with all physiological parameters described above, were monitored and recorded.

d. Statistical analysis of the data recorded is being conducted by the RZP personnel. This data is to be compared with that recorded from identical procedures using another adrenergic receptor antagonist labetolol, and one using a lesser dosage of propranolol. Preliminary results using one way analysis of variance and Duncan's new multiple range test with Kramer's correction factor for unequal sample size indicate that the time to death, from power on at 38.5°C, of the higher dose propranolol was significantly shorter than the low dose propranolol (2 mg/kg), labetalol and saline controls. The lethal colonic temperature was significantly lower for propranolol treated animals in both dosages, and labetalol, than for controls. These results, combined with results from studies with nadolol, and saline suggest that the beta-adrenergic receptors are involved in thermoregulation with no additional effect from alpha-adrenergic receptors. (Jauchem, Personal Communication).

IV.

PROJECT II: The Examination of Host/Graft Integration in the Rat Hippocampus Using Multiple Site Optical Recording

a. The other project I participated in involved the isolation of slices of living brain tissue in vitro. The animals used in this study were two year old male Spraque-Dawley rats. These rats had received selective lesions of the Dentate Gyrus within the hippocampus, produced by ionizing radiation. Control rats received sham exposure. Four months after irradiation or sham irradiation, selected rats received grafts of hippocampal or cortical tissue. Other rats received sham graft surgeries. These procedures produced the following groups: 1)Irradiated/hippocampal graft, 2)Irradiated/cortical graft, 3)Irradiated/Sham graft, 4) Sham irradiated/hippocampal graft, 5)Sham irradiated/cortical graft, and 6)Sham irradiated/sham graft. These procedures have been described previously by Mickley, et al. 1990.

b. During the course of my appointment at Brooks Air Force Base, these rats were transported to Brooks AFB from the Armed Forces Radiobiology Research Institute in Bethesda, MD., where they had been housed. I worked with a 1990 Summer Faculty Researcher, Dr. David Senseman, PhD. in his laboratory at the University of Texas at San Antonio. Dr. Senseman's lab has the facilities to perform a technique know as multiple sight optical recording. Optical recording allows the visualization of neuronal activity over a broad area simultaneously. This technique utilizes a voltage sensitive dye which responds rapidly, and in a linear fashion, to changes in membrane potential by altering its absorbance. Computer animation of these changes in the quantity of light received by a photodiode array, mounted atop a Zeiss microscope, allowed visualization of both the temporal and spatial organization of neuronal activity in the rat hippocampus. The ability to observe a broad area provides information about the functional integration of the graft tissue, thus

providing valuable insight into host/transplant relationships (Senseman, et al. 1990).

c. The rats were anesthetized with Metaphane, decapitated, and their brains removed from the skull. Each brain was bisected along the midline, and each hemisphere was mounted on a teflon block, medial side down using Cyanoacrylate glue. 400um sagittal sections of the living tissue were made using an oscillating tissue slicer. The tissue was kept alive throughout the experiment by constantly bathing it in artificial cerebrospinal fluid oxygenated with 95% O_2/5% CO_2.

d. Brain sections containing grafted tissue, or, in sham rats, sections of the corresponding area of the host hippocampus, were chosen for use. Slices were placed into a bath chamber containing a field stimulating electrode. The electrode was placed across the subiculum, a region posterior to the hippocampus containing the afferent fibers which travel to the hippocampus. The bath was then mounted on the stage of the Zeiss microscope, and the field electrode connected to a stimulator. We were also able to use a microelectrode to stimulate discrete regions of the host hippocampus, or to stimulate within the graft itself.

e. Stimulation of the afferent pathways to the host hippocampus produced neuronal activity in the host, but little was seen in the graft. Similarly, stimulation of the graft produced activity within the graft, but little activity was conducted into the surrounding host tissue. Generally, grafts of hippocampal tissue integrated better than grafts of cortical tissue. In addition, grafts of either tissue type found in ectopic locations integrated less well than those found within the dentate gyrus (Senseman, Personal Communication).

V. RECOMMENDATIONS:

a. The results of the study on thermoregulation suggest that the adrenergic control of thermoregulation is mediated by stimulation of

the beta-adrenergic receptors, with little input from the alpha-receptors. Propranolol is not selective for beta-1 or beta-2 type receptors. Consequently, I suggest that future research into thermoregulation in response to rfr exposure be conducted with selective beta-1 and beta-2 antagonists. This would provide further insight into the role of the adrenergic system in thermoregulation. In addition, selective agonists may be included. These agents should potentiate thermoregulator responses that are inhibited by propranolol.

b. Multiple site optical recording has proven to be an extremely valuable tool for use in inquiries into the functional activity of relatively broad regions of the brain. Such observations of neuronal activity in the hippocampus and olfactory bulbs have demonstrated its usefulness. This technique provides information about the spatial organization of activity that cannot be gained from single site recording methods. Further, it has demonstrated itself to be very useful for determination of functional integration of grafted tissue. This can be applied to any neural graft placed within the host brain. Both the lesion/graft replacement and multiple site optical recording techniques should prove very useful in future studies into the function of the intact brain, as well as in injured or degenerative conditions such as Parkinsonism, Alzheimer's and Huntington's diseases.

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FINAL REPORT

AN ELECTROPHORETIC COMPARISON OF THE EFFECTS OF VARIOUS CARBOXYLESTERASE INHIBITORS ON CHOLINESTERASE AND CARBOXYLESTERASE ACTIVITIES

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AN ELECTROPHORETIC COMPARISON OF THE EFFECTS OF VARIOUS CARBOXYLESTERASE INHIBITORS ON CHOLINESTERASE AND CARBOXYLESTERASE ACTIVITIES

by

Lisa Jones

ABSTRACT

Polyacrylamide gel electrophoresis was used to determine in vivo (administration of inhibitors to animals prior to sacrificing) and ex vivo (addition of inhibitors to serum following sacrificing) effects of tetraisopropyl pyrophosphoramide (Iso-OMPA), 2-(o-Cresyl)-4H-1:3:2:-benzodioxaphosphorin-2-oxide (CBDP) and pinacolyl methylphosphono-fluoridate (SOMAN) upon rat serum cholinesterase and carboxylesterase activities. Acetylthiocholine, butyrylthiocholine and naphthyl acetate, three commercially available substrates were used in this study. In general, CBDP and Iso-OMPA inhibited esterase activity following both in vivo and ex vivo administration. Significant inhibition was also observed following in vivo administration of SOMAN.

I. INTRODUCTION:

Among the esterases is an enyme known as carboxylesterase (CAE) which is present in numerous vertebrate and nonvertebrate organs and tissues [1]. Mammalian liver and serum carboxylesterase activity is particularly interesting to investigators examining detoxification reactions. Rodents (which were used in this study) are unusual mammals in that they have extremely high levels of CAE activity which can be completly inhibited without apparent effect. Serum and liver carboxylesterases are excellent enzymes for detoxification of organophosphorous compounds containing carboxylic ester substituents

[2]. Although liver carboxylesterase activity has long been recognized as important in xenobiotic detoxification, blood also appears to be an important detoxification site [3]. The detoxification capacity of CAE gives rodents substantial protection against organophosphorous compounds (compared to other mamalian species with low CAE activity).

Isozymes and multiple forms of carboxylesterases have been shown to exist and exhibit widely different and overlapping carboxylesterase substrate specificities [4-7]. Previously, Chambers et al. [Chambers, J.P., Hartgraves, S.L., Murphy, M.R., Kumar, N. and Valdes, J.J., IN PRESS] using a variety of ester substrates, showed naphthyl acetate hydrolysis to be very sensitive to CBDP. Surprisingly, these ex vivo investigations indicated Iso-OMPA to be considerably less inhibitory than CBDP. Thus, the question of whether a possible in vivo effect potentiates Iso-OMPA inhibition arises.

Since serum appears to be a complex mixture of esterase activities, separation of various esterase components from one another allows assessment of effects of various inhibitors upon individual component esterase activity. The purpose of this investigation was to contrast the effects of in vivo administration of various carboxylesterase inhibitors on cholinesterase and carboxylesterase activity to those of earlier ex vivo studies.

II. OBJECTIVE OF RESEARCH EFFORT:

The purpose of this investigation was to compare ex vivo and in vivo effects of various carboxylesterase inhibitors on cholinesterase and carboxylesterase activity.

III. METHODS: Electrophoresis was carried out as described by Chambers et al. [Chambers, J.P., Hartgraves, S.L. and Murphy, M.R., MANUSCRIPT

IN PREPARATION].

Preparation of Gels-Separating gels (7.5 %) were prepared by adding 4.95 ml distilled water, 2.5 ml 1.5 M Tris Buffer, pH 8.8 and 2.5 ml 30 % Bis-Acrylamide. The mixture was degassed for 15 minutes afterwhich 50 ul 10 % Ammonium Persulfate and 6.25 ul TEMED were added and allowed to polymerize for 45 minutes at room temperature. To the top of the polymerized separating gel was added 10 ml of a previously degassed gel solution comprised of 6.2 ml distilled water, 2.5 ml 0.5 M Tris Buffer, pH 6.8, 1.3 ml 30 % Bis-Acrylamide containing 50 ul 10 % Ammonium Persulfate and 10 ul TEMED. Combs (0.75 mm) are inserted and the stacking gel allowed to polymerize. Following polymerization, combs are removed and the wells rinsed well with deionized water. Prior to application of sample, the gel is subjected to electrophoresis at 200 volts for 1 hour. Sample protein is loaded into the respective wells and electrophoresed for 1 (25 ^{o}C) or 22 hours (5 ^{o}C) depending upon the substrate used.

Gel Staining-

1-Naphthylacetate-Gels electrophoresed for 1 hour at 25 ^{o}C were rinsed with deionized water three times following electrophoresis. Gels were incubated with 200 ml of 40 mM Tris Buffer, pH 7.1 containing 2.57 mM Fast Blue RR salt and 1 mM 1-Naphthylacetate for 30 minutes while shaking at room temperature. Following incubation, the substrate solution is poured off and the reaction is quenched by immersing the gel in 0.1 N Acetic Acid for 10-15 minutes at room temperature. Following quenching, the gel is washed well with distilled water.

Acetyl and Butyrylthiocholine-Following pre-electrophoresis, samples are loaded into wells and electrophoresed at 10 volts for 2

hours at 5 ^{o}C. After two hours, voltage is increased (50 V) and electrophoresis is continued for an additional 22 hours. Following electrophoresis, the gel is rinsed three times with water and once while shaking (1 hour) with a freshly prepared reaction mixture containing either 3.8 mM acetylthiocholine or butyrylthiocholine iodide. The mixture is poured off and the reaction quenched by addition of 3 M ammonium sulfate (1 hour at room temperature). Quenching solution is poured off and the gel is incubated for 10 minutes or until color is developed. Following development, the gel is washed well with deionized water.

IV. **RESULTS:**

a. Incubation of gels with acetylthiocholine-As shown in Figure 1, rat serum exhibits two major peaks of cholinesterase activity following electrophoresis. One activity (Peak A) migrated considerably slower than the other (Peak B). Partial characterization of these activity peaks was accomplished using 1) different substrates and 2) known cholinesterase inhibitors. Shown in Figure 2 are in vivo effects of Iso-OMPA, a known Butyrylcholinesterase inhibitor. Peak A is completely inhibited suggesting that this slower migrating species is Butyrylcholinesterase. Iso-OMPA exhibited little effect on the faster migrating activity. The insensitivity of the second peak to Iso-OMPA and its absence when assayed with butyrylthiocholine as substrate suggest that this species is representative of Acetylcholinesterase. Shown in Figure 3 are ex vivo effects of Iso-OMPA. Although inhibitory, it is not as inhibitory as in vivo administration of inhibitor. Surprisingly, CBDP, a known carboxylesterase inhibitor, significantly reduced the level of slower migrating esterase activity. This was also observed in

ex vivo serum as shown in Figure 4. Soman, a very toxic, organophosphate, completely inhibited the activity of both electrophoretic species (see Figure 5).

b. Incubation of gel with butyrylthiocholine-Only the slower migrating species was observed in the presence of butyrylthiocholine as substrate. Administration of Iso-OMPA to animals revealed inhibition of the slower migrating species as previously noted (Figure 6). Consistent with this inhibitory pattern is the in vivo effect of CBDP, indicating almost complete inhibition of the slower migrating species observed in the presence ofacetylthiocholine as substrate (Figure 7). Shown in Figure 8 are effects of soman using butyrylthiocholine as substrate indicating complete inhibition. In vivo treatment with Iso-OMPA and CBDP were consistent with previously observed ex vivo effects (Figures 9 and 10, respectively).

c. Incubation of gels with Naphthyl Acetate-Shown in Figure 11 is an electrophoretic profile of carboxylesterase activity (1 hour at 50 volts at 25 °C followed by development in the presence of naphthylacetate as substrate). As indicated in the figure, carboxylesterase activity migrated as a single, symmetrical species. The in vivo effect of CBDP, a known carboxylesterase inhibitor, is shown in Figure 12 indicating complete inhibition of naphthyl acetate esterase activity. In contrast, in vivo and ex vivo treatment with Iso-OMPA did not indicate the same degree of inhibition as observed for CBDP (Figures 13 and 14, respectively). Likewise, in vivo assessment of soman revealed only partial inhibition of carboxylesterase activity (Figure 15).

V. DISCUSSION:

Findings described here are consistent with previous _ex vivo_ experiments carried out in this laboratory indicating Butyrylcholinesterase to hydrolyze both acetylthiocholine and butyrylthiocholine (Figures 1 and 16, respectively). In contrast, Acetylcholinesterase hydrolyzed only acetylthiocholine. These observations further support the suggestion that the faster moving cholinesterase species is, in fact, Acetylcholinesterase. Each of the cholinesterase peaks could be identified after a 20 hour electrophoretic separation if presented with the suitable substrate. In contrast, carboxylesterase activity, the fastest migrating species, is clearly separated from cholinesterase activity after 1 hour of electrophoresis (Figure 11). Identification of this species as being carboxylesterase is supported by the fact that it is very sensitive to a known carboxylesterase inhibitor, CBDP (Figure 12).

Previously, experiments carried out in this laboratory demonstrated potent inhibition by CBDP of carboxylesterase activity using naphthyl acetate as the substrate. Although Acetylcholinesterase and Butyrylcholinesterase also hydrolyze naphthyl acetate, the amount of very fast migrating electrophoretic activity (Carboxylesterase) is many times greater than combined cholinesterase activity (as evidenced by the amount of unresolved esterase activity remaining at the origin following one hour of electrophoresis).

VI. CONCLUSIONS AND RECOMMENDATIONS:

This investigation supports previous studies indicating CBDP to be a potent carboxylesterase inhibitor both _in_ and _ex vivo_. Iso-OMPA also proved to inhibit both _in vivo_ and _ex vivo_. Consistent with earlier

findings of Chambers et al. [Chambers, J.P., Hartgraves, S.L., Murphy, M.R., Kumar, N. and Valdes, J.J., IN PRESS] is the *ex vivo* effect of Iso-OMPA. However, its greatest inhibitory effect was observed following *in vivo* administration. The effects produced by soman described in this report are consistent with the literature. *In vivo* patterns of cholinesterase activity were consistent with previous *ex vivo* experiments carried out in this laboratory. Additional experiments using more control and experimental animals are necessary.

Acknowledgements

This summer has proven to be a very rewarding experience. This is in part due to the Air Force Systems Command and the Air Force Office of Scientific Research for sponsoring such an experience and Universal Energy Systems for their courteous administrative efforts. I must not, however, overlook members of the School of Aerospace Medicine at Brooks Air Force Base. Dr. Russell Burton and Marilyn McConkey were very helpful during the screening process and in assuring me that this experience would be everything that it has been. I am very grateful to Colonel Stanley Hartgraves for affording me the opportunity of coming into his division. Additionally, I would like to thank Colonel Hartgraves, Dr. Murphy and Dr. Chambers for creating a project which would not only help them but, would also allow me to grow as a young scientist. Mrs. Marconi was instrumental in helping me get acclimated after a whirlwind arrival and her efforts are also appreciated. I would like to thank Stephanie Miller, Clarence Enos and Maxwell Williams for their support and technical expertise.

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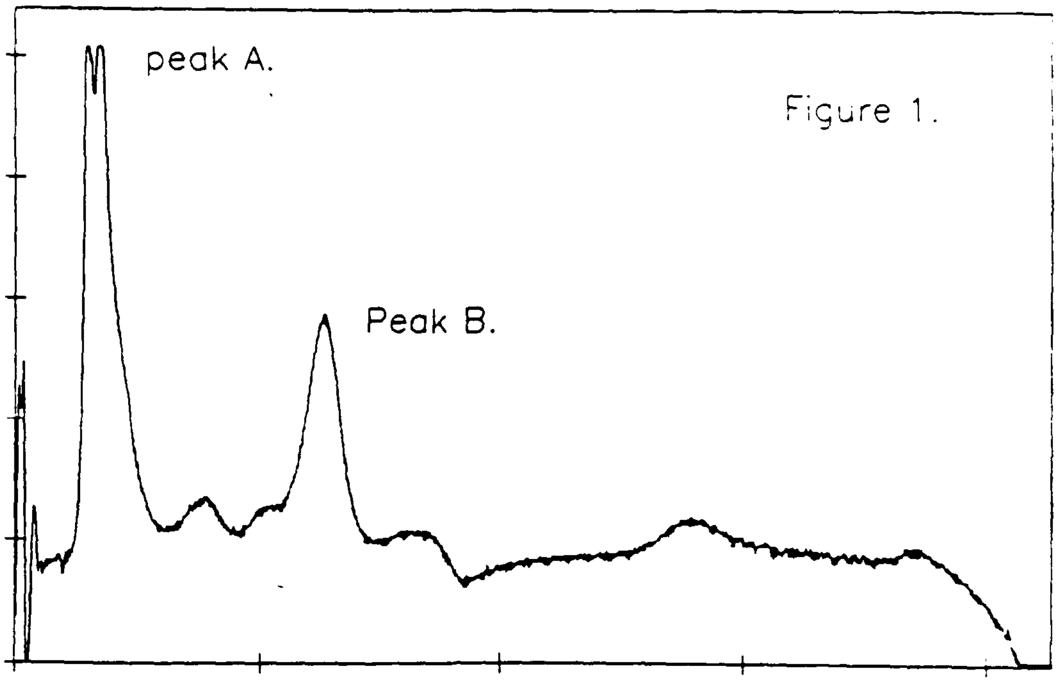
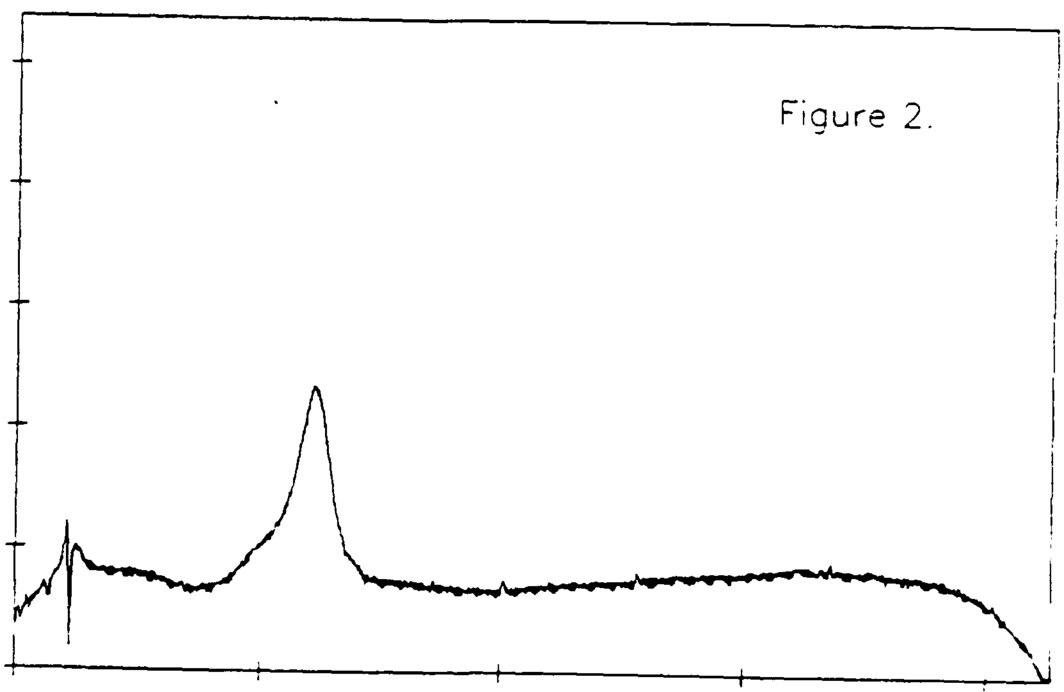
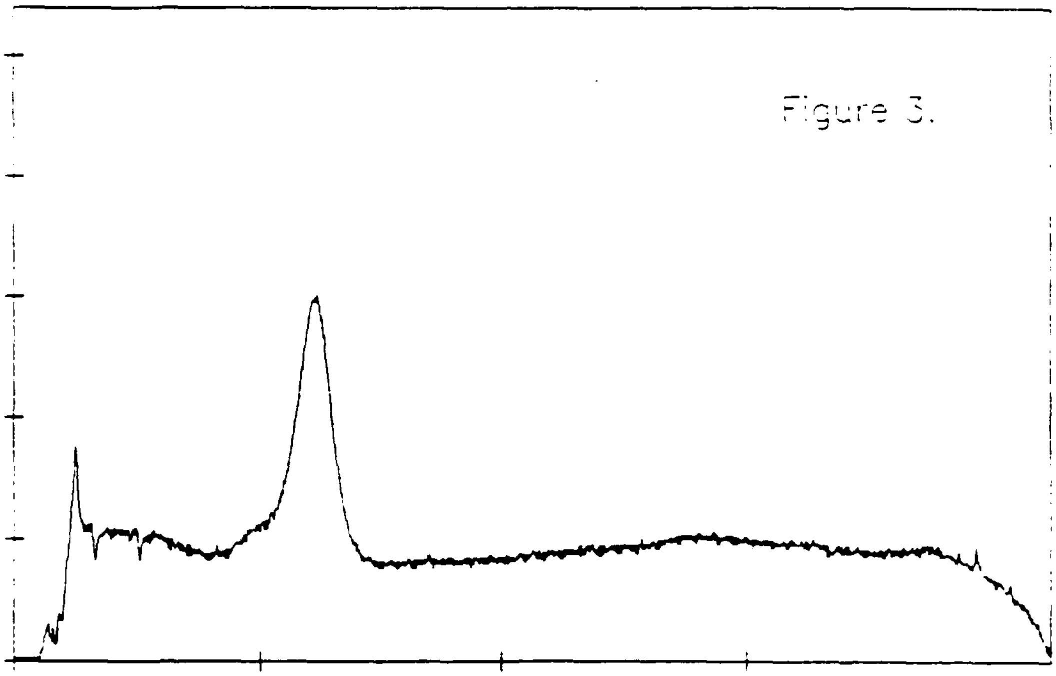
Acetylthiocholine Control with In vivo/ In vitro



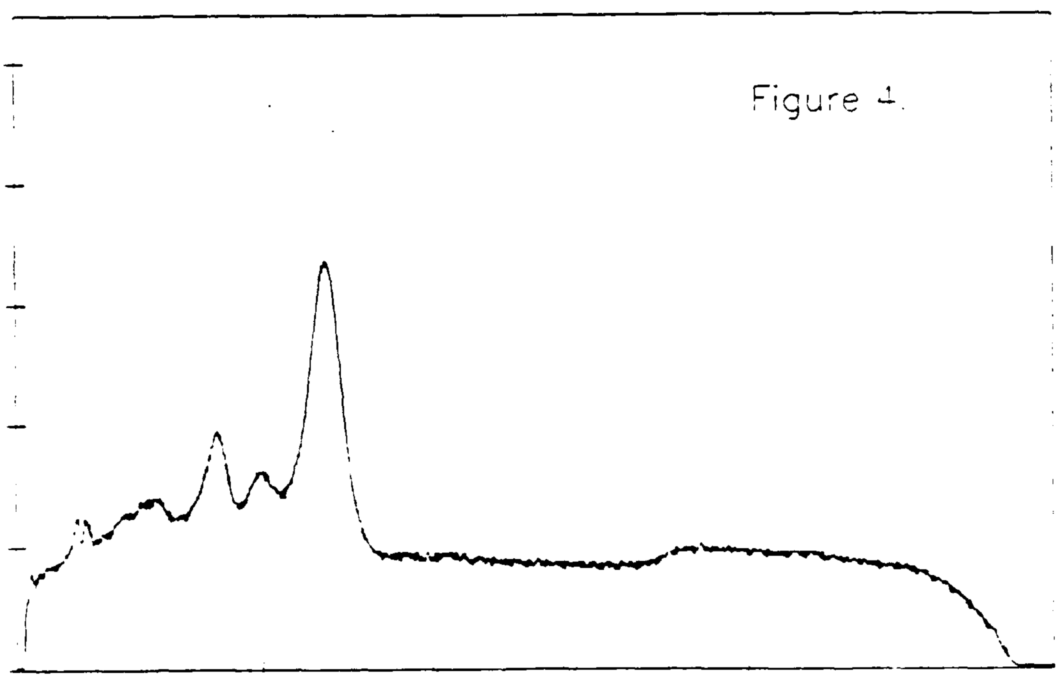
Acetylthiocholine with In vivo Iso-OMPA



Acetylthiocholine with In vitro Iso-OMPA



Acetylthiocholine with in vivo CBDP



Acetylthiocholine with In vivo SOMAN

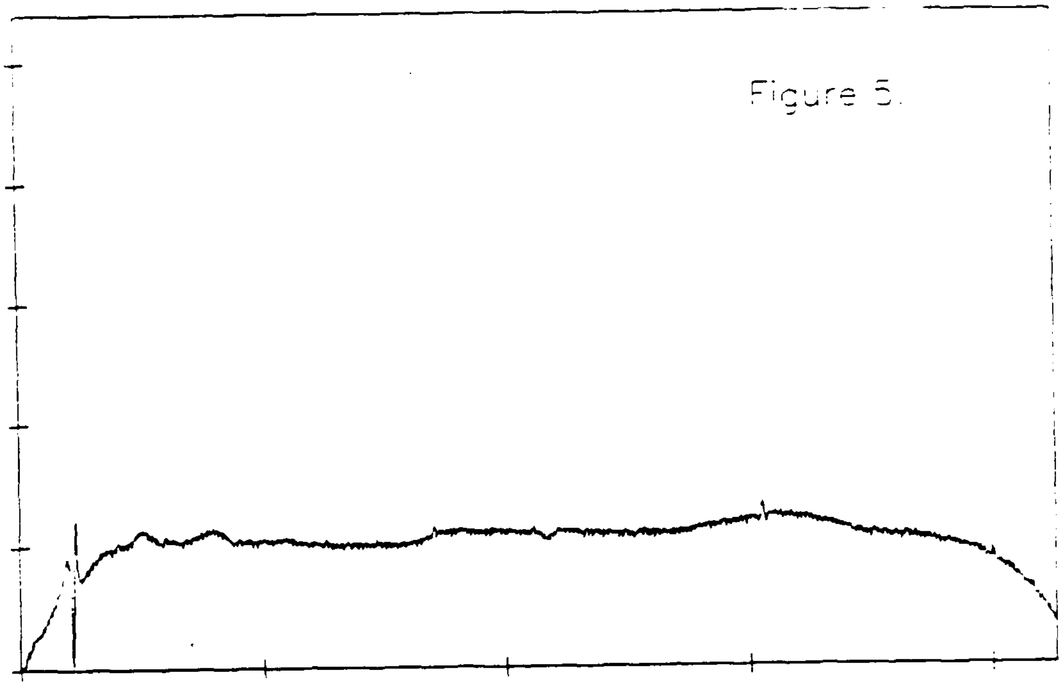


Figure 5.

Butyrylthiocholine with In vivo Iso-OMPA

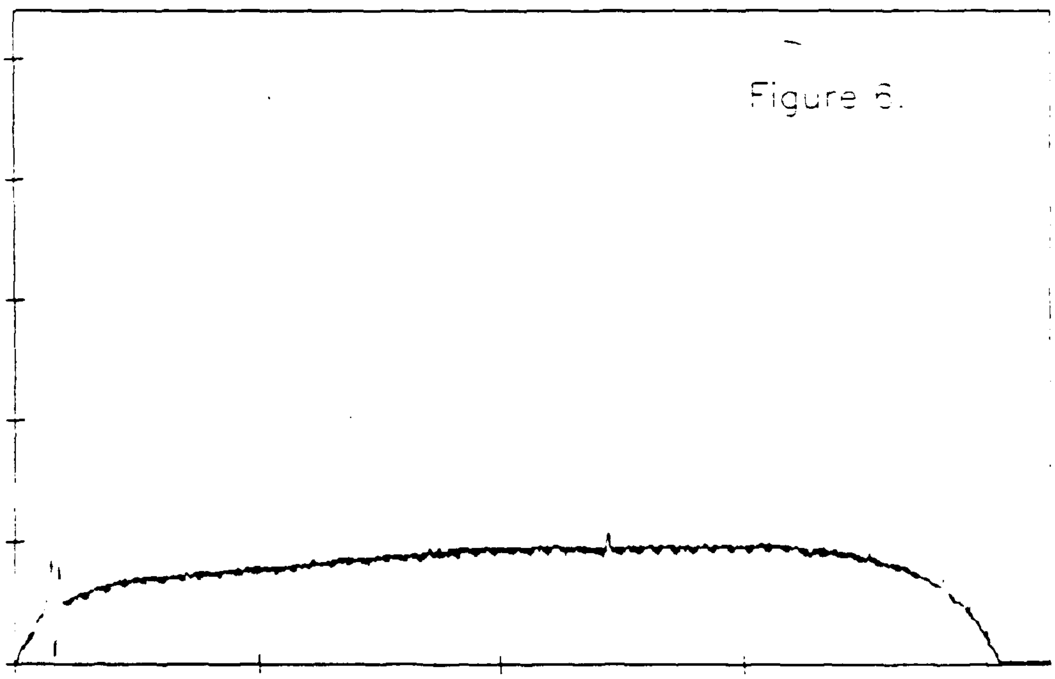
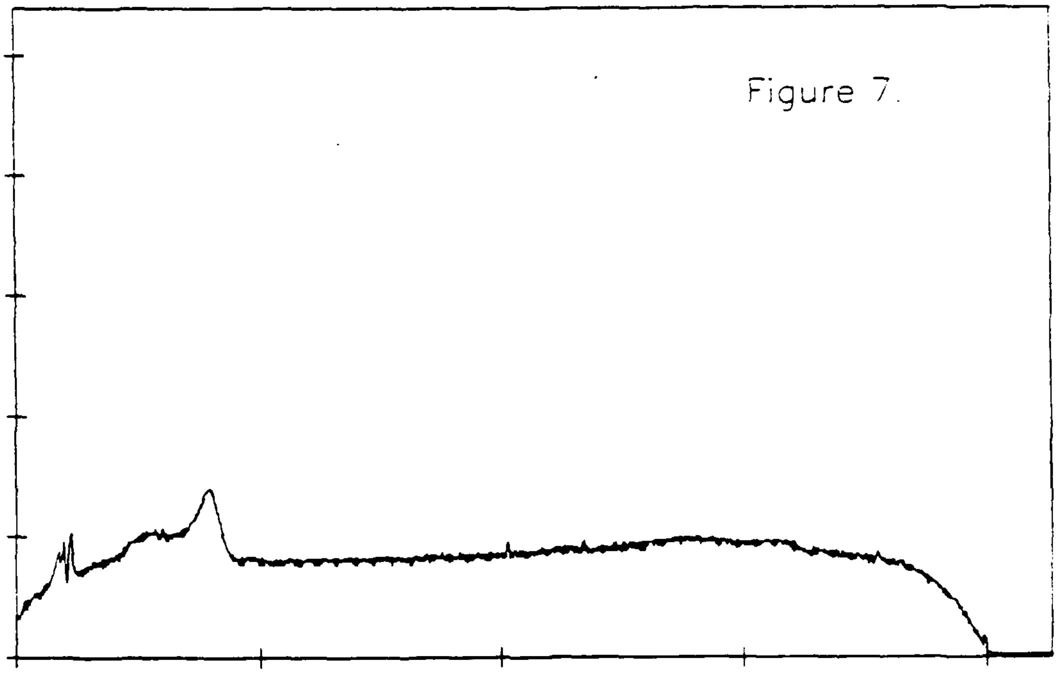
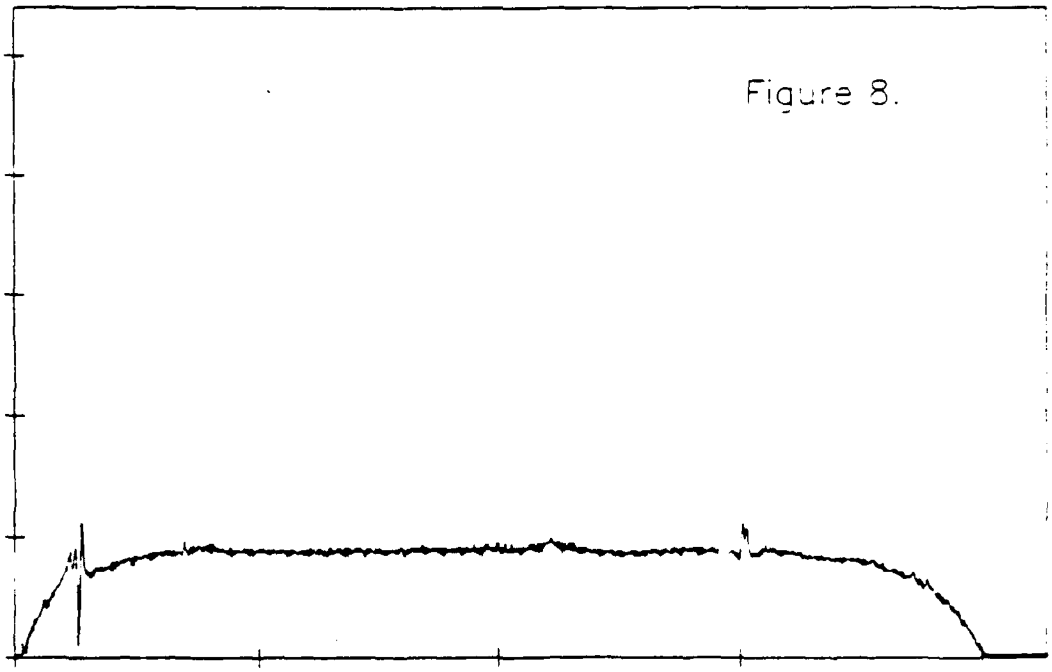


Figure 6.

Butyrylthiocholine with In vivo CBDP



Butyrylthiocholine with In vivo SOMAN



Butyrylthiocholine with In vitro Iso-OMPA

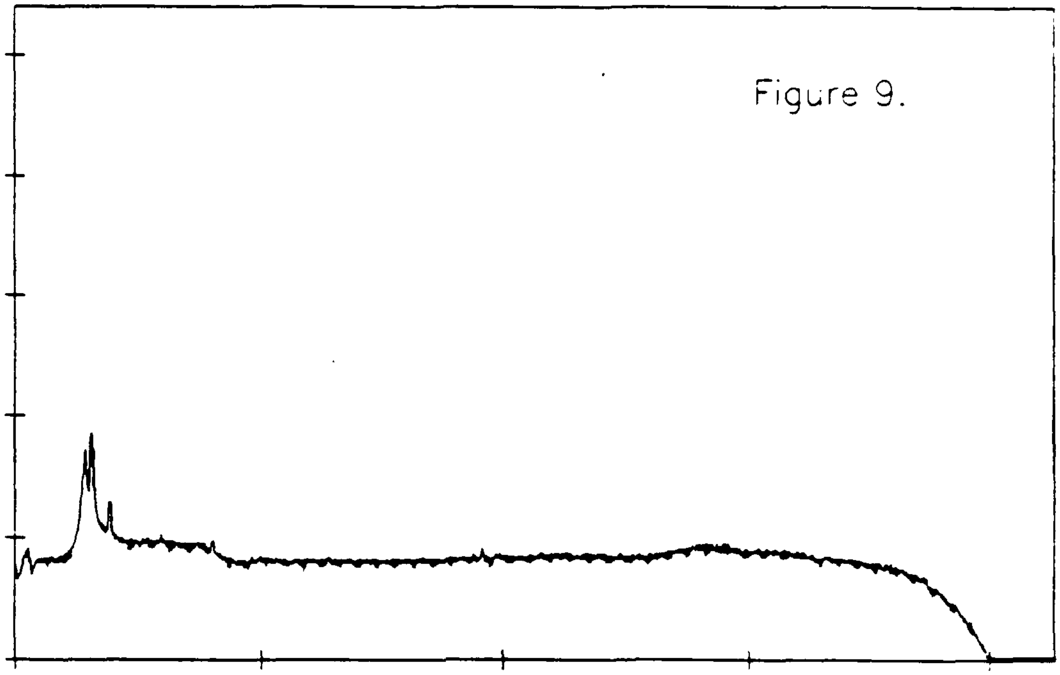


Figure 9.

Butyrylthiocholine with In vitro CBDP

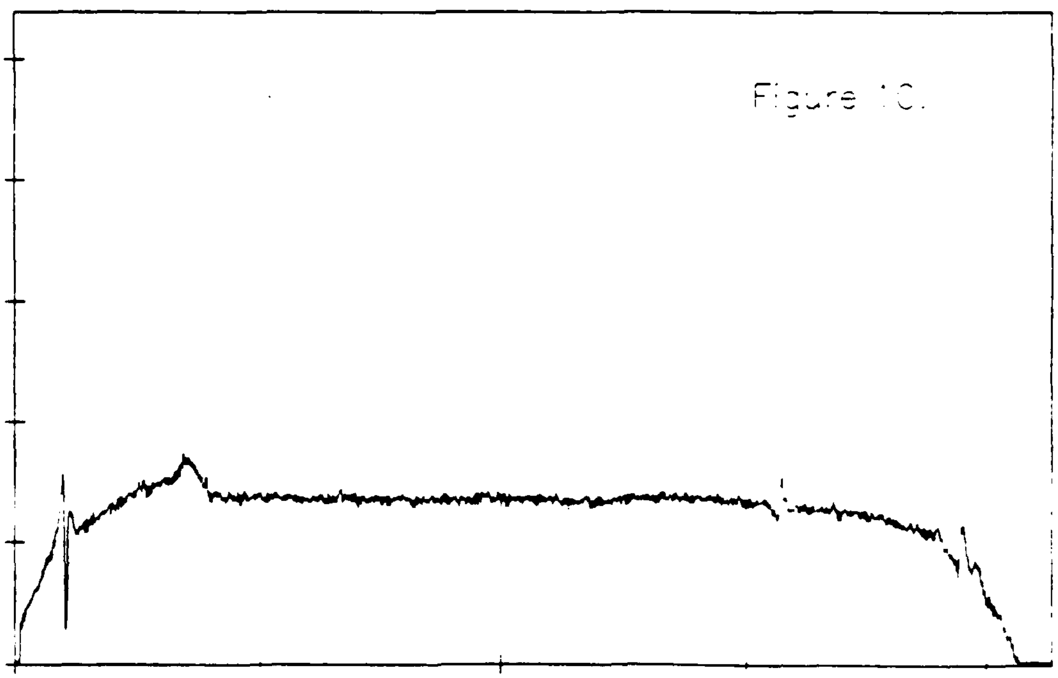
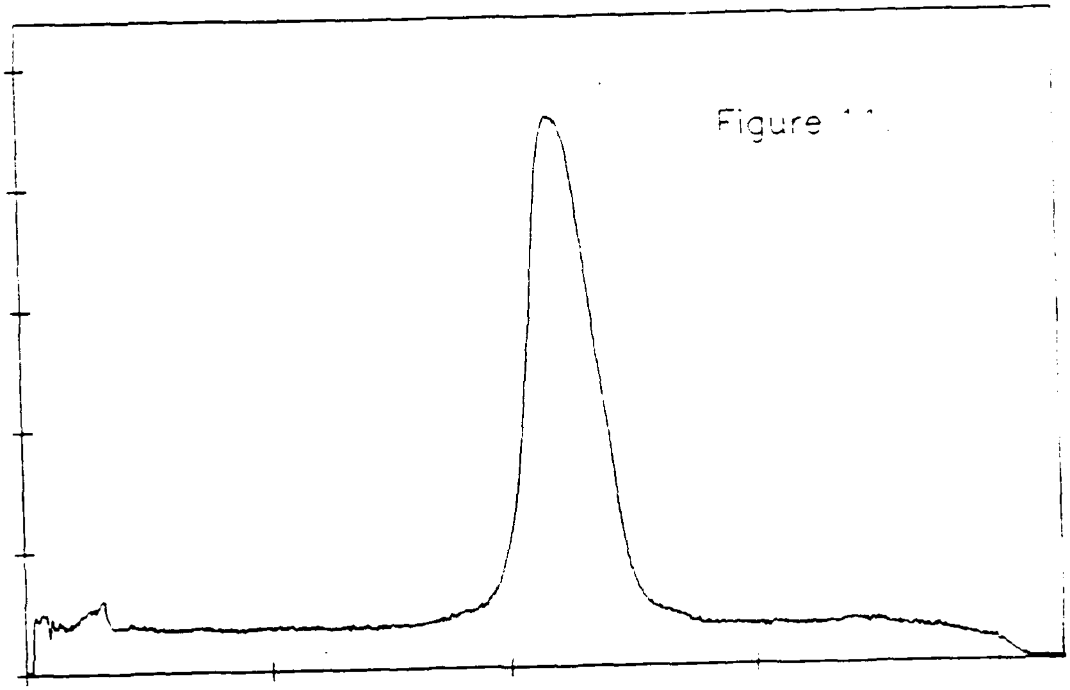
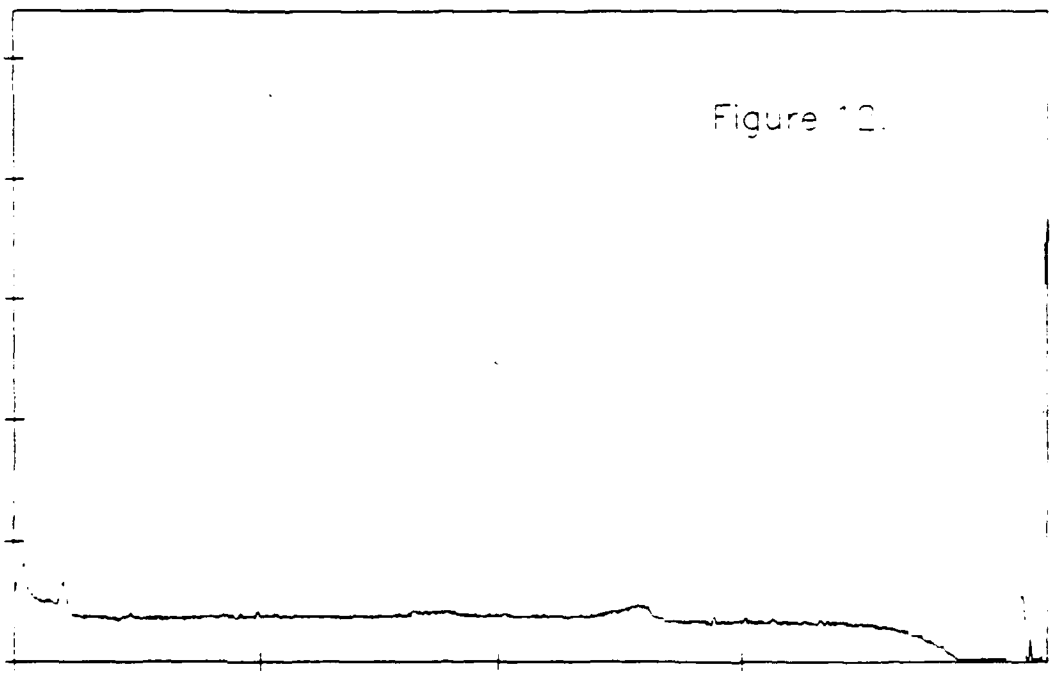


Figure 10.

1-Naphthyl Acetate Control with In vivo/in vitro



1-Naphthyl Acetate with In vivo CBDP



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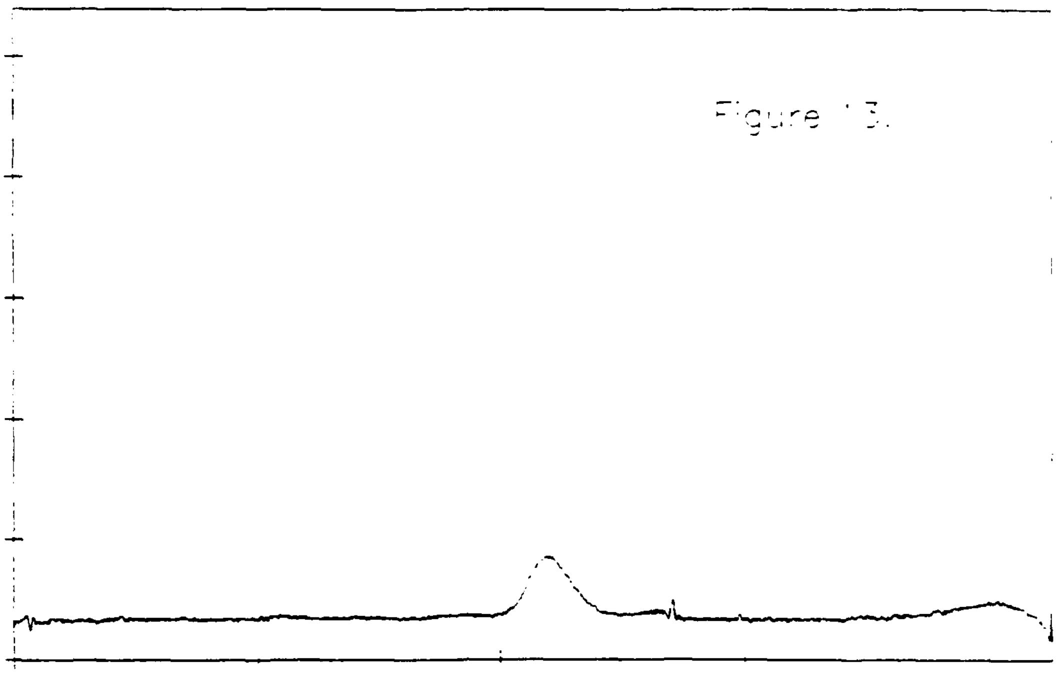
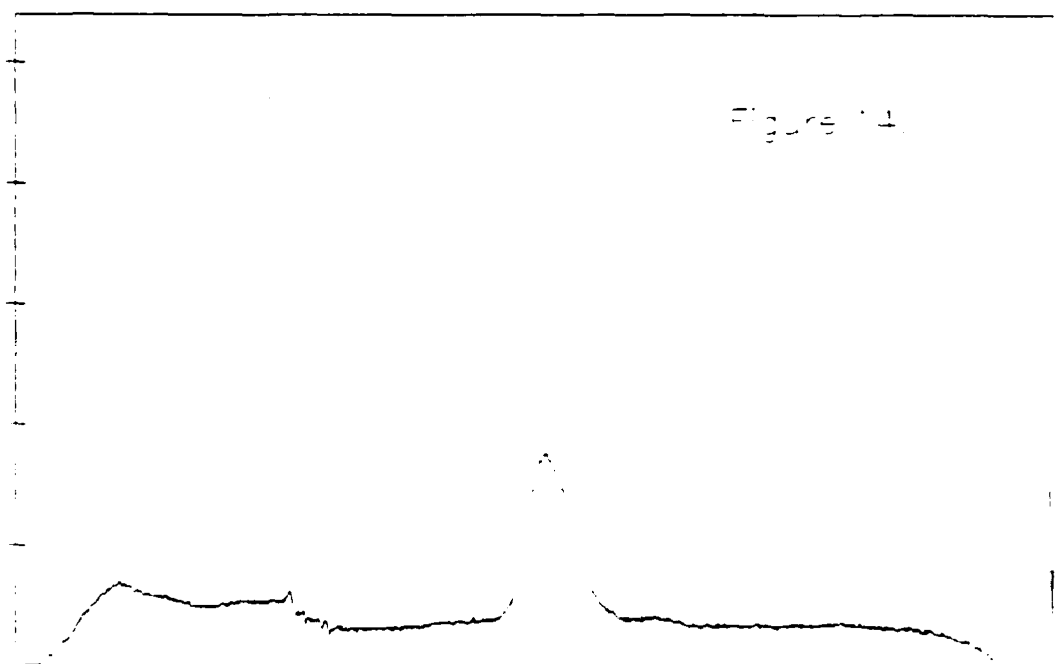
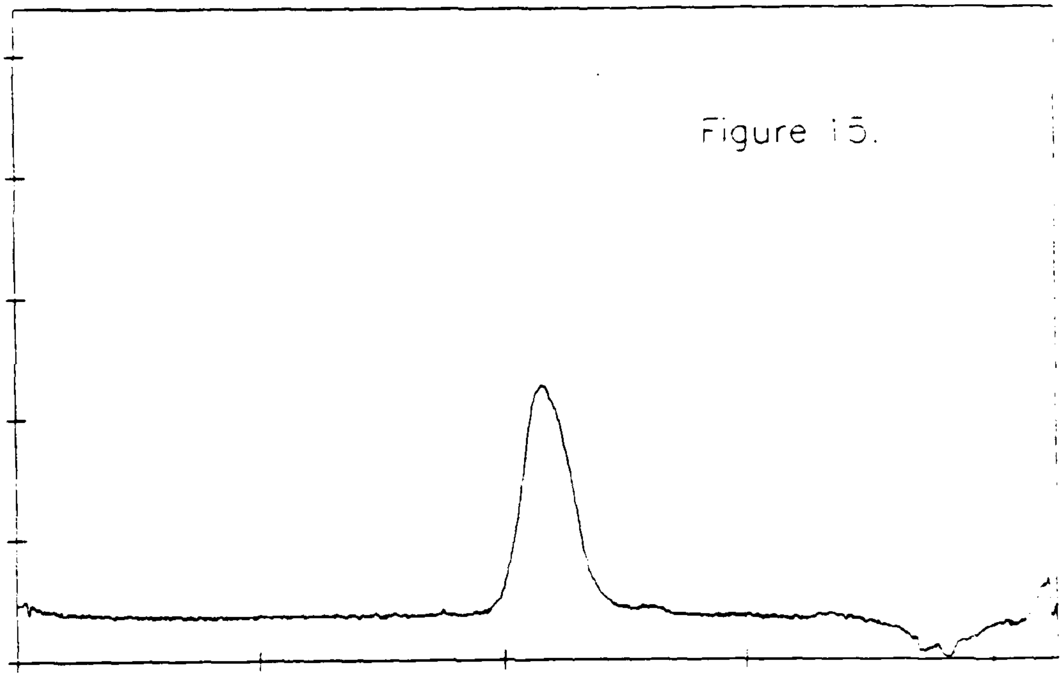


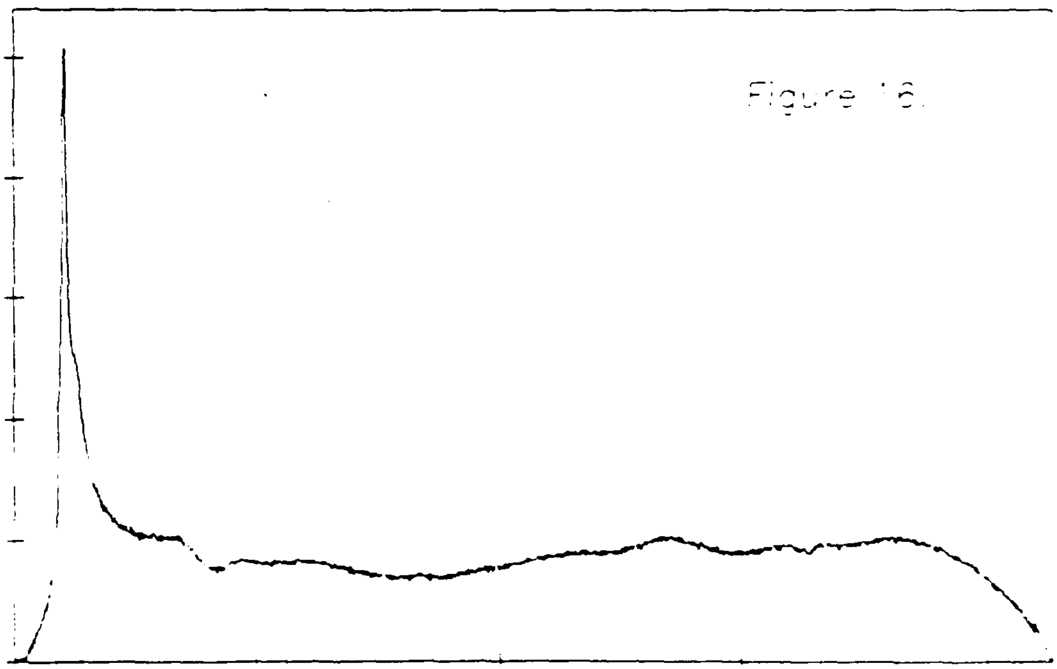
1-Naphthyl Acetate with In vitro Iso-OMPA



1-Naphthyl Acetate with In vivo SCMAN



Butyrylthiocholine Control with in vivo/ in vitro



No Report Submitted

Same as Prof. Rex Moyer

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FINAL REPORT

EFFECTS OF REPEATED DAYS OF LIGHT WORK AT MODERATE TEMPERATURES IN THE PROTECTIVE CLOTHING

Prepared by: Janet Solomon, Janis Beaird, James Kime

Academic Rank: Graduate Students

Department and University: Health and Human Performance Studies, University of Alabama

Research Location: USAFSAM/VNC
Brooks AFB
San Antonio, Texas 78235

USAF Researcher: Stefan H. Constable, Ph.D.

Date: 25 July 90

Contract No: F49620-88-C-0053

Same Report as
Janis Beaird
(GSRP)
(Report # 103)

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FINAL REPORT

Human Performance Model of Fatigue

Prepared by: Kelly J. Neville, B.A.

Academic Rank: Graduate Student

Department and University: Psychology Department, Rice University

Research Location: USAFSAM/VNB
Brooks AFB
San Antonio TX 78235-5301

USAF Researcher: Jon French, Ph.D.

Date: 24 August 90

Contract No: F49620-88-C-0053

Human Performance Model of Fatigue

by

Kelly J. Neville

ABSTRACT

A statistical model to predict the consequences of sleep deprivation on human performance over a 35 hr period was developed. A computer simulation utilizing the model was built with Micro SAINT 3.0 for demonstration purposes. A second computer program, written in PASCAL, was designed to facilitate use of the model as a descriptive and predictive tool.

The model consists of two equations: one describes the time course of accuracy; the other portrays the decay of response latency over time. An independent variable of both equations is the inherently cyclical body temperature which introduces the influence of the circadian cycle into the model. Another independent variable is the number of hours a person has been awake. Multivariate equations have produced performance degradation curves that account for 89.49 percent of the variance in composite response time data and 85.68 percent of the variance in composite accuracy data.

ACKNOWLEDGEMENTS

I could not have worked with a more harmonious and helpful group of people than I did during the ten weeks of this research project. It was a very educational experience and definitely a valuable one. I learned as much about doing research as I did about the area of my research project, which was quite a lot.

It was through the efforts of Drs. William Storm and Samuel Schiflett that I was able to participate in this program. They have both been especially supportive and I thank them deeply for their help and their concern. Dr. Jon French deserves special thanks, as well, for his contributions to making it possible for me to participate in this program. It was his contagious enthusiasm which most influenced me to pursue research in the area of human performance. His guidance has been invaluable; he has been unhesitatingly generous with his time and his knowledge, and from him I have learned an immeasurable amount.

I wish to express my appreciation to Dr. Russ Burton for coordinating this program at Brooks AFB and to the Air Force Office of Scientific Research for sponsoring it. I am also grateful to Universal Energy Systems, Inc. for arranging my fellowship on short notice and for assisting in the administrative aspects of the program.

I. INTRODUCTION

The serious problems of inefficiency and high accident rates during sustained operations and unaccustomed work shifts continue to prevail despite the growing body of literature on sleep deprivation, desynchronosis, and human performance. The military is one of many organizations with much incentive to control these disconcertingly persistent dangers.

Drs. Jon French and Samuel Schiflett of the Aerospace Research Crew Technology Branch of USAFSAM are involved in research to enhance performance of U.S. Air Force air and ground crews. The objectives of this effort are to enhance performance by developing countermeasures to diminish the effects of fatigue and desynchronosis (e.g., French, Hannon, & Brainard, in press; French, Boll, & Storm, in press). One goal of this project is to build a statistical model of sustained human performance which would assist in understanding the dynamics of fatigue.

Groundwork for this model was done prior to the beginning of the summer project term. A great deal of human performance data was collected and analyzed during a sleep deprivation study (French et al., 1990). Subsequently, modeling and computer simulation strategies based on this data were

formed by Dr. French and myself (Neville, 1990). This program has made it possible for these modeling strategies to be implemented and greatly improved.

II. OBJECTIVES OF THE RESEARCH EFFORT

The primary goal of this work was to generate a statistical model that describes human performance during sustained operations. Since physiological and time variables serve as independent variables to the model, the analysis and understanding of the relationships of these parameters with performance was vital.

A secondary goal was to create a simulation of human performance on a generic task during sustained operations for demonstration purposes. The simulation would allow the user to manipulate parameters in order to compare performance under different time and physiological conditions. It was to be built with the PC compatible modeling package Micro SAINT 3.0 (Seifert, 1979).

A third goal was to create a utility computer program to complement the simulation. This PASCAL program would allow the user to change parameters and equations. It's function would be to generate a range of predicted values, so that, as with the simulation, the user may easily evaluate and

compare different time and physiological conditions. Unlike the simulation, it would present the resultant output values for immediate evaluation.

III. OBJECTIVE I - STATISTICAL MODEL

A. Prototypical data generated in a 30 hrs awake performance study paradigm was used to build the model (French et al., 1990). The data was collected every 2 hrs from the 12 hrs awake time point (1800) to the 30 hrs awake time point (1200). It consisted of electroencephalogram (EEG) and temperature readings, eyeblink frequency, neuroendocrine levels, and performance scores on the Walter Reed Performance Assessment Battery (WRPAB) (Thorne, Gensen, Sing, & Hegge, 1985; Perez, Masline, Ramsey, & Urban, 1987) and the Complex Cognitive Assessment Battery (CCAB) (Hartel, 1988; Perez et al., 1987). Practice effects on the cognitive performance tasks were minimized by three practice trials between 1000 and 1600.

Ten subjects participated. The data of one who did not complete the study was disregarded. Five subjects were tested in each of two sessions. For the duration of each 30 hr test session subjects sat in adjacent booths. Each booth had a computer on which subjects independently performed

computer tasks. Food and bathroom breaks were permitted.

A number of the cognitive tasks demonstrated a significant overall decline in performance over time, especially during the early morning hours. Scores on these tasks were categorized as measures of accuracy (see Figure 1) or response time (see Figure 2). Average scores on individual tasks were normalized by dividing the average score at each of the nine time points by the average score at the trial 1 time point (1800) and multiplying by 100. The normalized scores of individual tasks in each category were averaged together to produce composite response time and composite accuracy scores. The number of hours awake and body temperature function as the independent variables of the model. These were averaged across subjects.

B. Initially, the attempt to generate predictive equations was confined to modeling the Serial Math (SM) task of the WRPAB, which was scored in terms of total time (ttime) on task (ttime), and the Numbers (N) task of the CCAB, which was scored by percent missed (% missed). A least squares method was employed which first considered only hours awake (ha), but later included body temperature (bt), as well, to model performance on the SM task, $\chi^2(6, \underline{N}=7) = .4665$, $p<.005$, with Equation 1 (see Figure 3), and on the N task, χ^2(6,

N=7)=5.3685, p<.750 with Equation 2 (see Figure 4).

$$\text{ttime} = -517.482 + 3.2588(\text{ha}) + 6.6047(\text{bt}) \qquad (1)$$

$$\%\ \text{missed} = 1776.631 + 0.2380(\text{ha}) - 17.9946(\text{bt}) \qquad (2)$$

Because these equations did not generalize to predict performance on similar cognitive tasks, the next modeling attempts utilized the composite accuracy and response time curves. Bivariate equations produced lines of close fit to the curvilinear slopes of the composite response time data, $\chi^2(6, N=7)=0.3931$, $p<.005$ (see Figure 5), and the composite accuracy data, $\chi^2(6, N=7)=2.1856$, $p<.005$ (see Figure 6).

$$\text{response time} = 168.9074 + 0.7378(\text{ha}) - 0.9839(\text{bt}) \qquad (3)$$

$$\text{accuracy} = -631.3464 - 1.5863(\text{ha}) + 7.5237(\text{bt}) \qquad (4)$$

Multivariate equations were able to model the composite curves even closer. Therefore, a third term in the form of

a variation of the hours awake variable was added. The resulting Equation 5 accounted for 89.49 percent of the variance in the composite response time scores (see Figure 7). Equation 6 accounted for 85.68 of the variance in the composite accuracy scores (see Figure 8). All parameter estimates for both equations were significant, $P<.0001$.

$$\text{response time} = -9291.8034 - 242.3934(ha) + 3508.5376(e^{bt}) + 2355864(ha/bt^2) \tag{5}$$

$$\text{accuracy} = 5545.597 + 162.283116(ha) - 2032.4895(e^{bt}) - 1577082(ha/bt^2) \tag{6}$$

IV. OBJECTIVE II - SIMULATION

A. The predictive equations of the model have been integrated into a computer simulation of sustained performance of a generic cognitive task. The simulation was built on an IBM-AT class computer with Micro SAINT 3.0. (Seifert, 1979). The simulated task consists of six interconnected nodes which represent a decision process and the decision outcome (see Figure 9).

B. The number of hours awake and an oral temperature value are entered into the simulation program by the user. The predictive equations utilize these values to produce an accuracy and a response time score. These scores determine the duration of the decision process and the probability that the correct decision will be made during each simulation. After one simulation trial, the default values of seven hrs awake and 98.0 degrees Fahrenheit replace the user's values and the simulation is repeated. Thus, the user is able to visually assess and compare general performance models under different physiological and time conditions.

V. OBJECTIVE III - UTILITY PROGRAM

A. In order to allow the model's predictions to be accessible and easily evaluated, the equations have been integrated into a PASCAL computer program. The program is built on an IBM-AT class computer.

B. The PASCAL program is designed to predict and graph hourly percentages of performance decrement across a 35 hr period given a particular body temperature value. It will do the same across the human body temperature range given an hours awake value of 35 hrs or less.

VI. RECOMMENDATIONS

A. The development of this human performance model will contribute to the understanding of the physiological and environmental elements that effect human performance. It may therefore prove to be quite valuable in the designing of work environments and work practices that would increase personnel alertness and efficiency. It is additionally an aim of the model to serve as a tool in delineating optimal work and rest cycles for individuals exposed to the dangers of fatigue in their work. The computer simulation and

particularly the PASCAL program, will serve as useful tools to persons responsible for scheduling these cycles.

B. Additional physiological parameters measured during the 30 hrs awake performance study which generated the source data will continue to undergo analysis to determine if any will contribute to the model's predictive ability. Candidates such as eyeblink frequency and EEG may dampen the sinusoidal tendencies introduced into the model by the circadian function of body temperature. In contrast, the inclusion of melatonin and cortisol levels is expected to strengthen circadian tendencies. These additions may strengthen the model's accuracy and replace the present third variable of the multivariate equations as more meaningful parameters.

While a high degree of consistency in the performance decrement of individuals across trials and across tasks has been demonstrated, great variability has been found to exist among individuals. Currently, the model describes only the average performance decrement on cognitive tasks; it is crucial that it be refined to consider this variation among persons. Further analysis of the relationships of physiological parameters with sustained performance will very

possibly reveal a correlation that is key to the accurate prediction of individual performance.

C. A follow-up project to the 30 hrs awake study will measure performance throughout a 36 hr period. This project should indicate the dependability and value of the model as a predictor of human performance during sustained operations. In addition, it will contribute to the extension of the prediction period and will reveal where improvements are needed.

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Figures may be obtained from

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FINAL REPORT

Aortic Input Impedance Calculation in Supine & Upright Baboon

Prepared by :	George C. Proicou
Academic Rank:	Graduate Student
Department and University:	Biomedical Engineering Center The Ohio State University
Research Location:	USAFSAM/NGIY/LACR Brooks AFB San Antonio TX 78235
USAF Researcher:	Ricky D. Latham, MD

Date:	30 Sep 90
Contract No.:	F49620-88-C-0053

Aortic Input Impedance Calculation in Supine & Upright Baboon

by

George C. Proicou

ABSTRACT

Chronically instrumented baboons were monitored as to the hemodynamic parameters of pressure and flow in the ascending aortic root, in both the supine and 70 degree head upright tilt state. The data on these parameters was amplified and recorded on a eight channel tape recorder and later filtered and down loaded to a floppy disk for data analysis using the personal computer based program DaDisp. From this analysis, the input and characteristic impedance was determined.

Acknowledgements

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems must be mentioned for their concern and help in all the administrative and logistical aspects of this program.

I would like to express my sincere thanks to the engineers and staff at the USAF School of Aerospace Medicine. Special thanks goes to the people in the Laboratory of Aerospace Cardiovascular Research (LACR). In particular I would like to thank Mr. Curtis White, Capt John Barber, and Msgt Rick Owens for their invaluable help with the instrumentation, the computer hardware and software, and the ways of getting things done in general. I would like to express my deepest gratitude to Dr. R.D. Latham for the opportunity I was given and the help and insight he imparted to me during the research and analysis phases of this project. Everyone's help in and out of the workplace made it a very rewarding and enjoyable summer.

I. INTRODUCTION:

There is an interest in describing the hemodynamic load upon the heart in both the supine and upright state. The cardiovascular system has been well characterized in the supine state, but there is a paucity of data describing the hydraulic function of the cardiovascular system in the upright condition.

The Laboratory of Aerospace Cardiovascular Research (LACR) is conducting ongoing studies into the area of cardiovascular response to changes in gravitational stress on the cardiovascular sysytem. From this research information on the ventricular and vascular performance in general can be derived and applied to the operational environment for aircrew of high performance aircraft.

My research interests include cardiovascular fluid mechanics as applied to the problems associated with the aerospace field as a whole. This as well as my background in aerospace engineering led to my assignment to LACR at USAFSAM.

II. OBJECTIVES OF THE RESEARCH EFFORT:

Currently, there is a lack of data available on aortic input impedance, hence pulsatile load, on the human or primate heart for the upright state (70 degrees head up tilt). Most studies describing input impedance in man have been obtained during elective cardiac catheterizations, which evaluates the supine posture only. Since man spends most of his life in the upright position, parameters and data measured in the supine position may not accurately reflect the chronic loading condition of the heart. Therefore, the main objective was to study a non human primate model, evaluating the pulsatile load on the left ventricle in both a supine and upright state. Another objective was to compare the results from the analysis performed by Fourier analysis with those obtained using a computer model characterizing the systemic arterial tree as a 3-element Windkessel.

III.

a. The model used in the study is a chronically instrumented baboon. Five animals were used in the research this summer. All data acquisition was done using approved techniques for animal research. The aortic flow was measured by a catheter mounted EMF flow probe, mounted with the proximal pressure

transducer housing. The pressure in the aorta was measured by placing a dual tipped Millar hi-fidelity 8 French catheter in the ascending aorta, see Figure 1. This procedure was done using a femoral artery cutdown with flouroscopic assistance for catheter manipulation. The animal was initially placed on a tilt table in the supine position. Flow and pressure measurements were then taken for about 1 minute. Cardiac outputs were also measured by thermodilution techniques. For accuracy, 3 outputs were usually taken and averaged. The animal, being secured to the table, was then tilted upright 70 degrees. Data and cardiac outputs were then measured as before. The animal was then tilted back to supine. This concluded the data acquisition.

The signals of pressure, flow and ECG (Electrocardiogram) were amplified and stored on a 8-channel R.E Vetter VHS data recorder. The data was then downloaded through a Precision Filter at 100 Hz cutoff with a 30 db/octave roll off to prevent antialiasing. The filtered signal was sampled at 500 Hz and digitized using Laboratory Workbench software on the Masscomp computer system. Supine and upright data were then extracted into their own files and then downloaded to a floppy disk. The data was then transferred to an independent workstation and final analysis was done using the software DaDisp.

Within DaDisp, a series of three to four consecutive cardiac cycles or beats from both the aortic pressure and flow were extracted and averaged. These representative beats of the pressure and flow were then calibrated: pressure based on the predetermined channel calibrations and the flow based on the cardiac output per cardiac cycle time.

Once these representative beats were derived, a Fast Fourier Transform (FFT) was performed on each to establish their respective frequency content. The magnitude and angle of the FFT's of the signals at the first 12 harmonics were then determined. The first 12 harmonics are the only ones of any real concern, since most physiological systems are fully described within this range.

From Ohm's law applied to fluid mechanics, the resistance, R, a fluid at a pressure, P, and traveling at a flow rate, Q, sees against its movement is given by

$$R = P/Q \quad (1)$$

This is true for a uniform steady state system, analagous to a direct current (d.c.) system in electrical terms. However, the cardiovascular system is anything but a steady pressure-flow system, being, in fact, a pulsatile one, analagous to an alternating current (a.c.) system in

electrical terms.

Now Ohm's law in an a.c. circuit takes on a variation from its d.c. couterpart such that:

$$Z_o = P/Q \quad (2)$$

Where Zo is the impedance the flow sees against its movement, and P and Q are the time dependent pressure and flow of the fluid, respectively. Now if the pressure is given by

$$P = Pe^{j(\omega t + \phi)} \quad (3)$$

and the flow by

$$Q = Qe^{j(\omega t + \theta)} \quad (4)$$

then the impedance Z is given by

$$Z_o = \frac{Pe^{j(\omega t + \phi)}}{Q e^{j(\omega t + \theta)}} \quad (5)$$

Now the impedance magnitude is simply

$$|Z| = |P| / |Q| \quad (6)$$

and the phase angle is given by

$$\phi - \theta \quad (7)$$

Now from the impedance results we are concerned with only a few of the frequencies given. At the zero harmonic or the fundamental frequency, we have Rp, the d.c. resistance. Averaging the third to the twelth harmonics, we arrive at the characteristic impedance, Zc, or the impedance the heart would see if the system was reflectionless.

Once it was felt that we had physiologically acceptable results, the calibrated flow and pressure were exported from DaDisp and input to a computer model, which is based on a 3 element windkessel, see Figure 2. The computer program then fitted a calculated flow to the measured flow. The program also calculated Rp and Zc based on the input aortic pressure and modeled flow.

b. As can be seen by the data results given in Table I, in all five animals the d.c. resistance, Rp, increased from supine to upright; however, in 2 of the animals the characteristic impedance, Zc, decreased going from supine to upright, while the opposite was true in the rest. The reasons for this are not quite known at this time.

In comparing the calculated parameters of Rp and Zc with those from the computer model, we see that three of the animals correlate well between the calculated and model, while the other two show some error. This error was due to the fact that the measured flow was very noisy in these animals and therefore the computer model could not handle the signal properly.

IV. RECOMMENDATIONS:

It is recommended that the research be continued. The research shows a tendency for Rp to increase in going from supine to upright. Whereas the dependence of Zc on position is still questionable; however, as preliminary results, the data does show promise for future research.

As the learning curve is applied to this research, the time to acquire, process, and analyze the data accurately will drop and the sample population will increase, giving statistical relevance to the data already analyzed.

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TABLE I

DATA RESULTS (in dynes*sec/cm**5)

ANIMAL #	A50	A106	A108	A114	A126
SUPINE					
calculated					
Rp	4129.5	2075.1	4592.6	3931.4	1989
Zc	65.5	34.8	36.2	102.2	70
model					
Rp	4708.3	2668.5	5913.8	3628.0	1877
Zc	47.3	43.2	45.4	285.1	93.4
UPRIGHT					
calculated					
Rp	4560.1	2705.8	5208.3	5849.5	3169
Zc	38.4	48.6	55.5	76.2	196.8
model					
Rp	4439.6	2475.7	5946.1	5132.6	2931
Zc	52.5	76.4	48.8	112.9	103

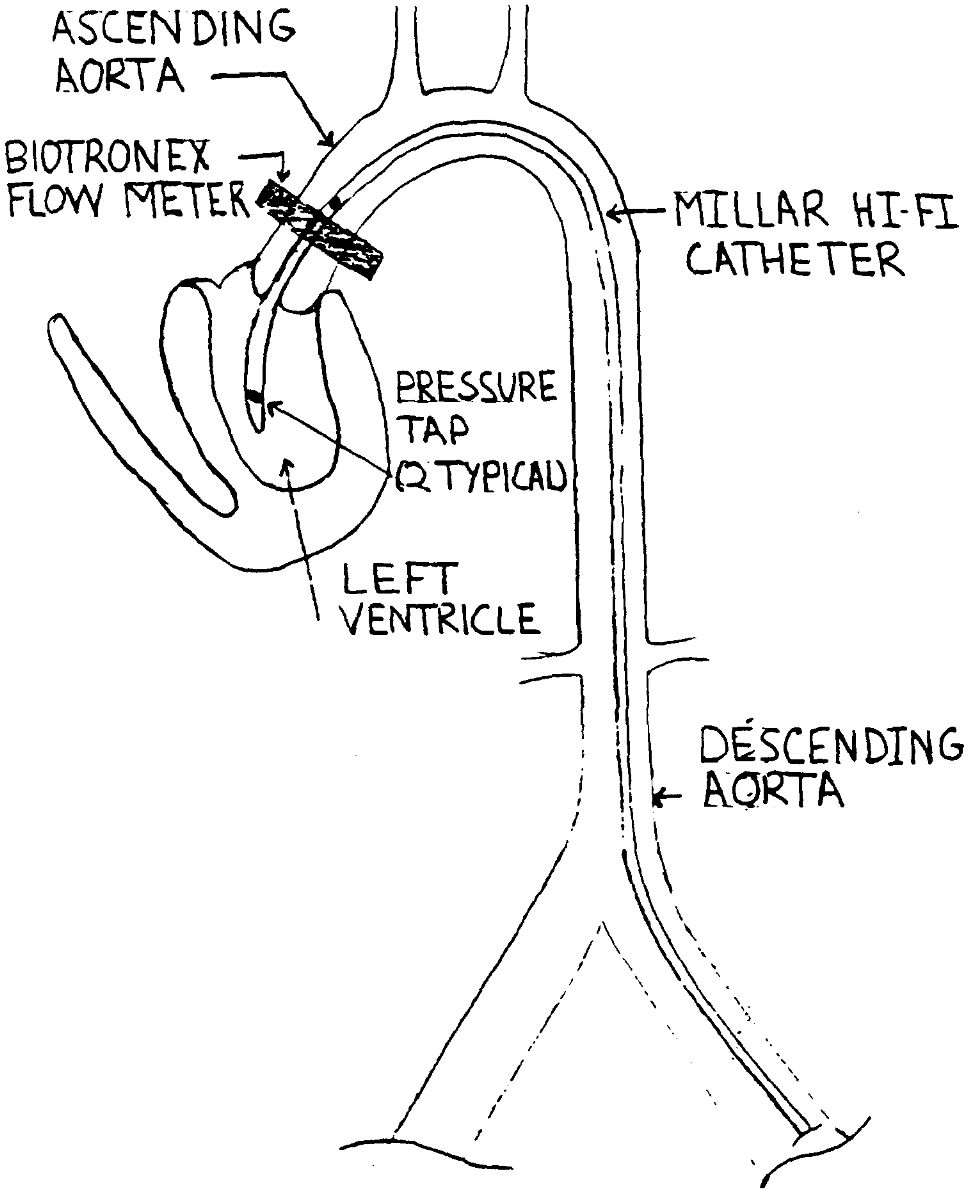

Figure 1. Schematic of Cardiovascular System

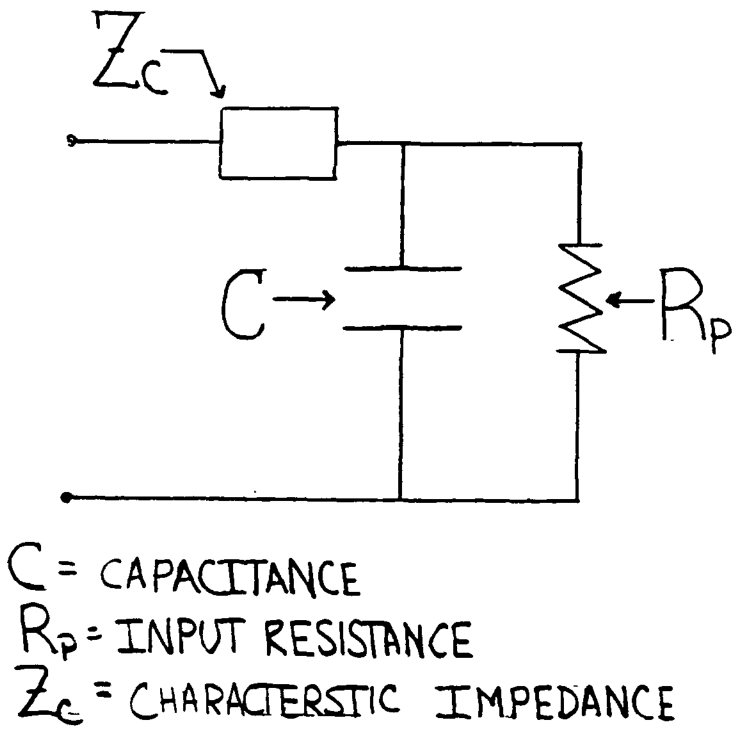

Figure 2. Schematic of 3-element Windkessel Model

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FINAL REPORT

A. Laser Protective Material Evaluation: Data Acquisition and Management System

B. Characterization of Nanosecond Laser Pulses Through Laser Eye Protection Materials

Prepared by: Dawnlee J. Roberson

Academic Rank: Graduate Student

Department and University: Engineering Department, University of Texas at San Antonio

Research Location: USAFSAM/RZV
Brooks AFB
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USAF Researcher: Capt Michael Mayo

Date: 5 Sept 90

Contract No: F49620-88-C-0053

A. Laser Protective Materials Evaluation: Data Acquisition and Management System

by

Dawnlee J. Roberson

ABSTRACT

A structured system was designed to obtain, compile, and organize the large amount of data collected during the test and evaluation of laser protective materials and devices. The system, when completed, will integrate data from two spectrophotometers, and save data to a format compatible with VAX statistical packages. This system will produce a summary data sheet containing laser densitometer, haze, prism, and spherical power measurements, along with spectrophotometer readings. The implementation of such a system has been left to Radiation Sciences personnel.

Acknowledgments

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems must be mentioned for their concern and help to me in all administrative and directional aspects of this program.

My experience was rewarding and enriching because of many different influences. Capt Michael Mayo provided me with support, encouragement, and never ending challenges. He, along with Dr. Paul Rudolf, constantly encouraged me to think and analyze. The help of SSgts Steve Ramsey and Craig Bramlette was invaluable in the technical portion of the many experimental setups tried. LtCol (Dr) Robert Cartledge's management support was greatly appreciated.

I. INTRODUCTION:

Collection of spectrophotometer data from the large number of laser eye protection devices submitted to the Biophysics function of the Vulnerability Assessment Branch of the Radiation Sciences Division of the USAF School of Aerospace Medicine (USAFSAM/RZV) has been an indiscriminate, inconsistent process. A simple, user friendly interface was needed.

USAFSAM/RZV is primarily concerned with laser protective materials for military use, therefore the large number of commercially available laser protective materials will be considered in a future parallel process.

My experience and academic background in computer science, analysis, and programming contributed to my assignment on this project.

II. OBJECTIVES OF THE RESEARCH EFFORT:

Collection of spectrophotometer data included using the manufacturer supplied software, moving the data from one machine to another personal computer (PC), converting data

from one format to at least three others, moving to another computer for printout, plus other time-consuming, frustrating tasks.

My assignment as a participant in the 1990 Summer Graduate Student Research Program (SGSRP) was to analyze this collection and output process, design a user friendly system, using currently available software and hardware, current and projected networking abilities. In addition, a flexible system was necessary to allow for future changes due to new technologies and/or requirements. The system has a database retrieval system for easy data access of already collected data in an interactive mode. The retrieval process output includes raw data output, spectral optical density and transmission plots, summary sheets, and pertinent comments unique to the application of the specific technology involved.

III.

a. The system under analysis was written and modified by many people with varying degrees of experience, and, as such, is not modular or globally integrated. The code was compiled at various times along the way, and so the portions of the source code were found in various places.

Documentation in the code was almost nonexistent. Current software users indicated a need for laser quality printouts, to include both text and graphics. A sample suggested printout was provided by the users, with the understanding that it was only a guideline and should remain flexible. Minimum information was provided as required output as was the need for special "nice to have" output if technically possible and within the scope of the existing systems.

b. I would have preferred to use the C programming language for this project, but the users currently had a copy of Turbo Pascal 5.5, and indicated that they already knew it relatively well. Turbo Pascal is easy to learn and maintain, so it was decided to have the code written in it. Suggested minimum documentation requirements were provided. I was not to write code, but was to be available to advise those writing the code. I designed the data flow and described what each module was to do. One user interface was suggested to be written in BASIC 7.1 for better screen control.

IV. RECOMMENDATIONS:

a. USAFSAM/RZV has access to a small programming section. To prevent this problem of fragmented programming happening

again, they should utilize readily available resources. These programmers are trained in modular programming, and data retrieval systems. This system should take approximately one man-month to complete the coding and testing assuming good knowledge of requirements, and the programming language to be used. Another man-month would be required to incorporate the large amount of previously obtained data into the database management system.

b. USAFSAM/RZV has several years of data collected that are currently stored on floppy disks. Statistical information should be completed on this data, but RZV personnel do not have the time or knowledge for completion of this task. This information should be saved to a mainframe database and statistical values calculated.

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2. Turbo Pascal: User's Guide, Borland Int'l, 1989.

3. Dale, Nell and Chip Weems, Introduction to Pascal and Structured Design, D.C. Heath and Company, Lexington, MA, 1988.

B. Characterization of Nanosecond Laser Pulses Through Laser Eye Protection Materials

by

Dawnlee J. Roberson

ABSTRACT

A literature search was performed on the interaction of laser radiation, from cw to short pulse, with laser absorbing medium such as saturable absorbers. In addition, the topics of dynamic bleaching, laser induced non-linear optical effects, thermal effects, and short pulse laser fluorescent spectroscopy were thoroughly searched. An experimental system was designed to characterize the spot size, thermal coefficient, time for laser penetration of materials, and incident power on the attenuating factor (optical density) of an argon-ion laser absorbing material.

I. INTRODUCTION:

Radiative energy transfer and/or laser induced change in optical density may occur when a laser absorbing material is irradiated by laser radiation. Initial studies have shown that certain laser absorbing materials used in protective devices will initially absorb the incident laser radiation and then temporarily change states and allow the material to transmit higher than expected energy levels. Some of the incident laser radiation can also be absorbed and retransmitted in a different optical band (radiative energy transfer). Different factors affecting this "dynamic bleaching" can be temperature, background illumination, incident laser power, spot size, pulsewidth, and the characteristics of the absorbing dye used in the laser protective material. Laser protective materials are used in many places: military operations, medical facilities, university and research laboratories. It is imperative that the overall transmission of the device be quantified under the <u>specific</u> conditions in which it will be used. The overall safety factor for the user of the material must be emphasized.

The Biophysics function of the Vulnerability Assessment

Branch of the Radiation Science Division of the School of Aerospace Medicine (USAFSAM/RZV) is concerned primarily with the level and mechanism of how this radiation is transmitted as well as the damage thresholds of the optical material in use. These situations are dangerous because hazardous levels may be transmitted into the eye causing permanent blindness, flashblindness, or glare.

My background of both biology and engineering allowed me to have an unique perspective on this problem. I understood the basics of lasers and how the eye works, which contributed to my assignment to this task.

II. OBJECTIVES OF THE RESEARCH EFFORT:

This problem requires more than can be done by one or two qualified persons in a year. I was directed to complete the literature search on all of the topics mentioned in the introduction. The temperature requirement was added at a later date. I was to bring USAFSAM/RZV personnel up-to-date on recent research done in these fields. Additionally, I was to design an experimental setup with equipment on hand to begin preliminary data collection on a particular

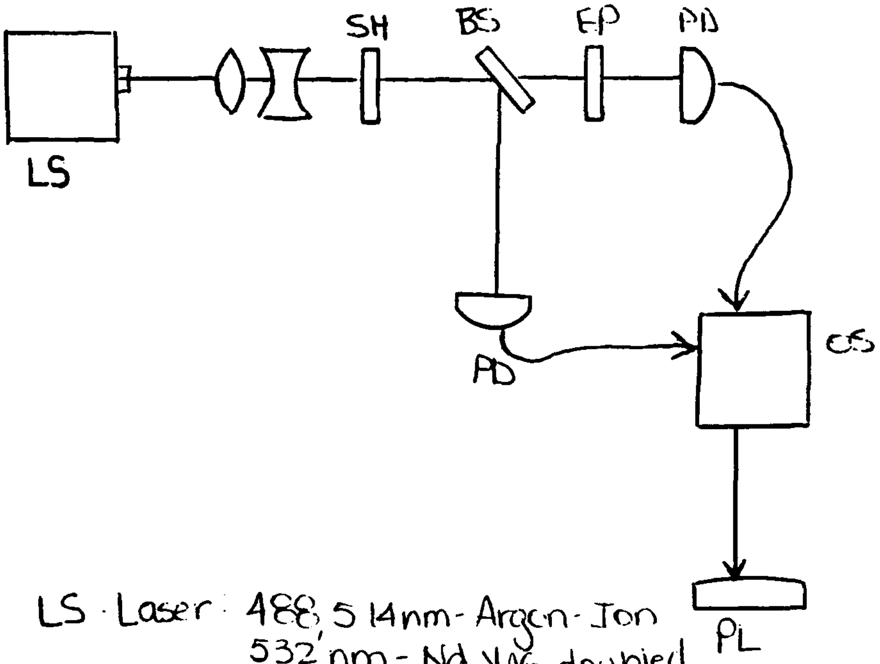
material/absorbing dye combination designed to attenuate the radiation from a continuous wave argon-ion laser.

III.

a. Initially, I began the search reading several articles RZV personnel provided. I then spent several weeks at local university libraries searching for articles, and cutting the list of potential articles to a manageable 20 or so. I read through several recent texts on these topics. Discussion and recent articles pointed out that temperature might have an effect. I expanded the search to include thermal effects. I have copies of all the significant articles, and have begun to develop a test plan for this project.

b. The experimental setup required for initial data collection was very similar to several of those listed in the papers referenced. Figure 1 is a layout of that experimental setup. The material (polymethyl methacrylate, PMMA) being tested was run at a a variety of temperatures, ranging from 10C to 75C. Freezing was accomplished by using a chemical refrigerator, and heating was accomplished by using a hot air gun or an autoclave.

IV. RECOMMENDATIONS:



LS · Laser · 488, 514 nm - Argon - Ion
532 nm - Nd YAG doubled
SH Shutter
BS Beam Splitter
PD · Photo Diode
EP · Experimental Plastic
OS - Oscilloscope
PL · Plotter

Figure 1. Experimental Setup

a. The military and commercial uses of such an saturable absorber are widely varying. Depending on the material and/or dye used, the chemical "switch" to allow amounts of laser light thru can be extremely short (picoseconds or shorter), or long (seconds or longer). Currently, saturable absorbers are primarily used for laser pulse compression and optical Q-switching. This switch has no mechanical parts, and so cannot mechanically wear out; however, many of the dyes used in saturable absorbers degrade over time and therefore have finite lifetimes. For these materials to be completely safe for use as a laser protector, all quantifiable measurements should be taken, verified, and the mechanism understood. The literature has shown that physicists/chemists are unable to explain this phenomena at this time.

b. Follow-on research should continue in this area. The limited data collection I was able to do indicated that some absorbers embedded in plastics actually allow more laser light through than expected. The low incident power used in the data collection, along with the results, indicate that some materials used in protective devices are not adequately protecting against the laser radiation for which it was designed - by as much as two orders of magnitude below the

protection level measured using incoherent radiation at the same wavelength. Military uses for such protective materials need more extensive evaluations to verify that, in fact, protective materials are doing what they are designed for. I tested two plastics, one worked very well, and one did not under identical incident laser conditions.

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FINAL REPORT

THE EFFECT OF MICROWAVE RADIATION ON THE EYE

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USAF Researcher : Dr. Thomas J. Tredici

Date: 25 Oct 1990

Contract: F49620-88-C-0053

THE EFFECT OF MICROWAVE RADIATION ON THE EYE

by

Robyn C. Robinson

ABSTRACT

An Air Force examination team performed ophthalmologic examinations on thirty-eight subjects. All were military personnel who had sustained microwave overexposure over the permissible exposure level set by U.S. Safety Standards of 10 mw/cm^2. The intent of the study was to determine if there were any changes in the eye and whether these changes could be attributed to microwave overexposure. No lens changes were found that could be attributed to microwave overexposure. Thus, this study does not support the contention that microwave exposure in the military environment over 10 mw/cm^2 is cataractogenic.

Acknowledgements

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems must be mentioned for their concern and assistance to me in all organizational and directional aspects of this program.

My experience was enjoyable and rewarding because of many different influences. Dr. Tredici served as an excellent mentor and role model. Dr Poitrast and Noel Montgomery provided me with technical information and interpretation of complex data. Drs. Dennis, Miller and Peterson, Sgts. Patrao and Rozkydal all helped to make my working environment pleasant. The support,encouragement and concern of Ralph Miles was greatly appreciated.

I. INTRODUCTION

In the current literature there is a debate over the effect of microwave radiation on the formation of cataracts in humans. The increasing use of microwave by the military service and civilians is of chief concern due to the occupational hazards experienced by personnel who work with radar. Animal models of microwave radiation have been far more conclusive than human epidemiologic studies.

The Ophthalmology Branch of the Clinical Sciences Division of the United States Air Force School of Aerospace Medicine is particularly concerned with the possible cataractogenic effects of microwave radiation. My research interests are in determining whether cataractogenic effects are dose-related, using a population of military personnel who were inadvertently exposed to varying dosage of microwave radiation. I am working on this project with Thomas J. Tredici M.D., Senior Scientist, Ophthalmology Division, U.S. Air Force School of Aerospace Medicine, Brooks AFB, Texas.

II. OBJECTIVES OF THE RESEARCH EFFORT:

The current PEL of 10mw/cm^2 has been shown to present an insignificant thermal to the body. The mechanism of action of cataract induction in the eye is related to excessive heating of the lens.

My objectives as a participant in the 1990 Graduate Student Research Program (GRSP) was to determine if there were any cataractous changes induced in the eyes of military personnel who were inadvertently exposed to varying dosages of microwave radiation. Previous studies had examined the effect of microwave radiation on the human eye, however, none had correlated any changes in the eye with the amount of radiation exposure.

During my 1990 GRSP several important data were analyzed. Comprehensive medical examinations of military personnel including ophthalmologic exams are performed initially at the time of exposure and periodically followed-up. The results of these exams were correlated with the amount radiation to determine if dose-related injury relationship existed.

III.

Excessive exposure to electromagnetic radiation has been shown to harm various human organ systems. One ongoing argument concerns the effect of microwave on the body. The avascularity of the lens prevents sufficient cooling, thus it is more susceptible than the rest of the body to thermal damage from exposure to microwave radiation. In sufficient doses it has been reputed by some authors to cause cataracts in animals and humans. Other writers have concluded that no such lens changes have been observed in humans and that the 10 mw/cm^2 permissible exposure level (PEL) renders adequate protection.

The USAF Occupational and Environmental Health Laboratory of the Aerospace Medical Division visits each site after an incident of overexposure to reconstruct and quantitate the amount of radiation exposure experienced. The present permissible exposure level (PEL) of 10 mw/cm^2 has been shown to present an insignificant thermal load to the body. The question has been posed as to the potential hazards of microwave radiation experienced greater than 10 mw/cm^2. It has been suggested that the mobility of the subject is a critical factor is determining whether the eye will be damaged. Thus, it is hypothesized that humans do not acquire cataracts because, in addition to the protective nature of the anatomical configuration of the eye,they are mobile when exposed. Similarly, Rhesus monkeys do not experience any lens damage if they are allowed to be mobile while being irradiated. Only laboratory animals which were immobilized and

bombarded intraocularly with microwave radiation experienced lens damage.

The U.S. School of Aerospace Medicine has compiled a repository of 38 individuals who have been accidentally irradiated by microwave energy above the PEL of 10 mw/cm^{2}. these subjects have been examined from 1974 through 1986. The exposure levels ranged from a low of 18 mw/cm^{2} to a high of 14,400 mw/cm^{2}. These exposures have all been verified at the site. A complete physical exam has been completed on each of the subjects, with special attention given to any lenticular or retinal pathology. The lenses of the eyes of personnel exposed to radiation are intensely scrutinized for damage. Photos are also taken of the lenses in these subjects.

Some of the subjects complained of feeling an increase in warmth when irradiated, others had headaches, and some felt nauseated after the incident. One has been noted to have questionable bone lesion on his skull. None complained of a decrease in visual acuity, blurring or increase in glare. To date, our original and repeat examinations have not discovered any pathology that can be attributed to microwave radiation.

IV. RECOMMENDATIONS

Continued monitoring of dosages of microwave radiation received in overexposure incidents, evaluation of health

status at the time of the incident and stricter adherence to safety precautions are necessary. Although conclusive evidence of the cataractogenicity of microwave radiation in humans could not be established, long-term follow-up evaluations of these patients may provide new answers to this question.

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FINAL REPORT

PCR Analysis of Ureaplasma urealyticum and Mycoplasma hominis

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USAF Researcher: Ferne K. McCleskey

Date: 3 August 1990

Contract No: F49620-88-C-0053

Same Report as
Prof. Vito Delvecchio
(Report # 151)

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FINAL REPORT

SODIUM DODECYL SULFATE POLYACRYLAMIDE GEL ELECTROPHORESIS FOR THE RESOLUTION OF LIGHT INDUCED FOS-RELATED PROTEINS IN THE HAMSTER SUPRACHIASMATIC NUCLEI

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Date	:	December 5, 1990
Contract No.	:	F49620-88-C-0053

Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis for the Resolution of Light Induced FOS-Related Proteins in the Hamster Suprachiasmatic Nuclei

by

Sveta Singh

Recent studies suggest that expression of the proto-oncogene, c-fos, represents an early step in the response cascade leading to light-induced alterations in the phase of the circadian pacemaker and, ultimately, to photic entrainment of circadian rhythms. Brief light pulses administered during the subjective night result in (1) permanent phase alterations of pacemaker output and (2) a transsynaptic increase in c-fos protein *(FOS) immuno*-reactivity in neurons of the suprachiasmatic nucleus (SCN). To determine if the FOS immunoreactivity is indeed FOS protein, nuclear proteins from the SCN of light-stimulated Syrian hamsters were subjected to sodium dodecylsulfate polyacrylamide gel electrophoresis (SDS-PAGE) followed by Western analysis using a polyclonal antiserum raised against FOS. A 45 kDa protein which (1) was immunoreactive for FOS, (2) was blocked by preabsorption with synthetic FOS peptide, and (3) appears to correspond to the FRA-1 antigen was identified, indicating that the immunoreactivity was, indeed, FOS-

related. However, technical difficulties prevented the identification of other FOS related antigens and further work is necessary. The procedures developed during my tenure at the School of Aerospace Medicine provided a foundation for future studies of the role of c-fos expression in light-induced alterations of the circadian pacemaker.

ACKNOWLEDGEMENTS:

I wish to thank the Air Force Systems Command, Universal Energy Systems, and the School of Aerospace Medicine for the opportunity to be involved in basic research at the Neuroscience Labratory, Aerospace Research Branch. This research experience proved to be a rewarding and enriching endeavor. The laboratory staff provided support, encouragement, stimulation, and an abundance of assistance in overcoming the many technical difficulties that were encountered. Anna Marie Michel's interest in all aspects of this research greatly aided in its progress. I would also like to thank Kathryn Hart, Heather Alexander, and Heather Neville for a truly enjoyable working atmosphere.

INTRODUCTION:

The suprachiasmatic nuclei (SCN) are the site of localization of the light-entrainable circadian pacemaker in mammals (Rusak and Zucker, 1979). Bilateral destruction of the SCN causes loss of any behavioral circadian rhythms including activity, drinking and eating and sleeping (Rusak and Zucker, 1979; van den Pol and Powley, 1979), as well as endocrine circadian rhythms of corticosterone secretion (Moore and Eichler, 1972). Entrainment of circadian rhythms to the environmental light-dark cycle is mediated by a direct pathway, the retinohypothalamic tract (RHT; Renz et al., 1987). In addition, an indirect pathway has been described which projects from the ventral lateral geniculate nucleus, the geniculohypothalamic tract (GHT; Rusak and Zucker, 1979). Although the GHT may play a role in the photic responsiveness of the SCN (Boulos and Rusak, 1982), lateral geniculate ablation studies indicate that the RHT projection is sufficient for entrainment of the circadian clock (Dark and Asdourman, 1975). The neurochemical basis of the photic entrainment process is unknown.

The c-fos gene is one of a family of immediate early genes (Sheng and Greenberg, 1990) which are induced in the absence of new protein synthesis by numerous agents. A number of studies indicate that fos is involved in regulatory mechanisms of cell replication and specific

differentiation pathways. Recent observations of c-fos expression in various cell types, including neurons (Dragunow et al., 1989), suggest that the c-fos gene may function in the regulation of transcriptional events which underlie neuronal plasticity. Increased c-fos expression occurs in response to a variety of physiological and pharmacological stimuli in nervous system tissue. Rea (1989; Rea and Michel, 1990) and others (Rusak et al., 1990, Aronin et al., 1990) reported that retinal illumination induces c-fos expression among a population of neurons in the SCN. Furthermore, FOS expression occurs only in response to light pulses which reset the circadian pacemaker, suggesting that c-fos expression may represent an early step in the response cascade leading to light-induced alterations in pacemaker function. Recent work conducted in the Neuroscience Laboratory, USAF School of Aerospace Medicine, indicated that different cell populations may be responsible for phase delays versus phase advances of the pacemaker. To insure that light-induced FOS-immunoreactivity is indeed indicative of the presence of FOS protein, SDS-PAGE/ Western analysis of FOS immunoreactivity in SCN extracts was conducted.

OBJECTIVES:

A) Determine if light increases FOS-related protein immunoreactivity in the hamster suprachiasmatic nucleus.

B) Determine if FOS immunoreactivity in SCN neuronal nuclei is indeed FOS protein.

METHODS:

Light Stimulation Procedure

Adult, male Syrian hamsters (Mesocrecitus auratus) were maintained in the USAFSAM animal facility under LD 14:10 (lights on at 2000). After 3 weeks under LD 14:10, the hamsters were transferred to individual cages equipped with computer-monitored running wheels and maintained under constant darkness for 14 days. During this period, the free-running circadian activity rhythm was monitored. Using the onset of wheel running activity as a phase reference point (defined as circadian time (CT) 12) animals received single 15 minute pulses of 33 lux of white light at CT 18 (i.e., 6 hours after the onset of activity) on day 15 under constant darkness as described elsewhere (Rea, 1989). Exposure of animals to light pulses at CT 18 result in phase advances of the circadian pacemaker of approximately 1.9 $\pm$ 0.8 hrs (Rea and Michel, 1990). After stimulation, the animals were returned to darkness.

Preparation of SCN Cell Nuclei

Two hours after the onset of the light pulse, the SCN from 3 hamsters were removed, collected in 3 ml of ice cold 0.32 M sucrose, 3 mM $MgCl_2$, 1 mM Hepes (pH 6.8; SMH), and homogenized in a Potter-Elvehjem homogenizer with a motor driven teflon pestle. The crude homogenate was transferred to a centrifuge tube and diluted with 0.6 vol of SMH and 0.22 vol of H_2O. The diluted homogenate was carefully underlaid with 0.8 vol of SMH and centrifuged in a swinging bucket rotor at 1,000 X g for 10 min. The supernatant was removed and the pellet completely resuspended in 5-10 mls of 1.8 M sucrose, 1 mM $MgCl_2$, 1mM Hepes (pH 6.8) and spun at 50,000 X g at 4 C. The pellet was recovered in 100-200 ul of 0.25 M sucrose, 1mM $MgCl_2$, and 1 mM Hepes (pH 6.8) and frozen at -80° C. Five or 10 µl aliquots were measured for protein using the Lowry Assay.

SDS-PAGE Procedure

After obtaining the pellet, electrophoresis was performed using a vertical slab apparatus and 1.5 mm-thick polyacrylamide gel slabs. The separating gel consisted of 10% acrylamide (acrylamide:bisacrylamide ratio = 37.5:1), 0.1% SDS, 0.04% TEMED, 0.1% ammonium persulfate, 1.5 M Tris (pH 8.8). Acrylamide:bisacrylamide (37.5:1) was prepared as a 30% stock solution. SDS was prepared

as a 10% stock solution and ammonium persulfate was freshly made as a 10% stock solution. The separating gel solution was prepared in a 250 ml vacuum flask by mixing in 6.3 ml of 1.5 M Tris. This solution was immediately poured between the glass plates. The wells were formed using a 10-tooth comb which was removed from its support to allow insertion into the gel. No airspace was left between the well former and acrylamide solution. The gel was allowed to polymerize at room temperature for 45 min and was used the same day. As the combs were removed, the wells were floated with distilled water to avoid distortion of the sample wells and drying of the gel.

The lower and upper electrophoresis chambers were filled with running buffer consisting of 200 mM glycine, 0.1 % SDS in 25 mM Tris-HCl (pH 8.3). Before loading the gel, the nuclear preparations and standards were boiled for 5 minutes in 50 mM Tris HCl (pH 6.8) containing 10% glycerol, 2% SDS, 0.1% bromphenol blue, 5% beta-mercaptoethanol. Aliquots equivalent to 30 ug of protein were used for analysis. Electrophoresis was performed at a constant voltage of 150 mV for 2 hours.

The gel was removed from the apparatus and either stained or electrophoretically transferred to nitrocellulose membrane for Western analysis. Staining of the protein bands was achieved using 0.025% Commassie Brilliant Blue in 45.4% methanol, 5% acetic acid. The

gel was destained in 45.4% methanol and 5% acetic acid for band visibility. For electrophoretic transfer, the gel was equilibrated for 10 minutes in transfer buffer consisting of 250 mM glycine, 0.1% SDS, 60% methanol in 25 mM Tris-HCl (pH 8.3) and transferred overnight at 20 V to nitrocellulose membranes (Schleicher and Schuell BA 85) which were presoaked in buffer for 5 minutes.

Western Analysis of Fos-Related Proteins

After the transfer, membranes were incubated in blocking solution (5% nonfat dried milk in PBS-tween) for 1 hour then placed in this solution containing affinity purified FOS antiserum at a dilution of 1:1000 for 1 hour. This antiserum was raised against synthetic M-peptide, corresponding to residues 127-152 of the Fos protein (Curran et al., 1987; kindly donated by Dr Michael Iadarola, NIDH) and may recognize other Fos-related antigens (Franza et al., 1987). Nitrocellulose membranes were washed 4 times in blocking solution for 10 minutes each.

Immunoreactive bands were visualized by Enhanced Chemiluminescence (ECL; Amersham). Membranes were incubated with biotinylated goat-antirabbit IgG, followed by a preparation of avidin-biotin-HRP complex (Vector Labs). After washing extensively in blocking buffer, the membranes were incubated for 1 minute in ECL reagent,

blotted dry, wrapped in Saranwrap and exposed to X-ray film (Amersham ECL) for 5 - 120 seconds.

RESULTS

Previous work using cultured cells has shown that the FOS antiserum employed in this project recognizes three FOS related antigens with molecular weights of 62 kDa (c-fos), 45 kDa (FRA-1) and 35 kDa (FOS-B). Unfortunately, two high molecular weight (70 kDa and 65 kDa) bands were present in the nuclear extract which bound the HRP reagent even without prior exposure of the membrane to FOS antiserum. Blocking experiments indicated that these proteins may contain bound biotin. Due to this unanticipated complication, we were unable to demonstrate conclusively that all three FOS antigens were present in the nuclear extracts. Nonetheless, a 45 kDa immunoreactive band corresponding to the FRA-1 antigen was detected. This band was blocked by preabsorption of the FOS antiserum with synthetic M-peptide, indicating that the band specifically bound the FOS antiserum.

RECOMMENDATIONS:

It is difficult to suggest any type of recommendations given the fact that the results were inconclusive. However, based on previous research, the following suggestions may be incorporated into the protocol to obtain more information:

A) Using [^{125}I]-labeled protein A followed by autoradiography to visualize the FOS antigens.

B) Scanning of the autoradiograms with a densitometer to quantitate the amount of fos present.

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FINAL REPORT

EFFECTS OF REPEATED DAYS OF LIGHT WORK AT MODERATE TEMPERATURES IN THE PROTECTIVE CLOTHING

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GRADUATE STUDENT RESEARCH PROGRAM

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FINAL REPORT

Physiological Effects of Whole-Body Exposure to Millimeter Waves

and

Physiological Effects of Alpha-antagonist Tolazoline During Whole-Body Exposure to 2.45 GHz Radiofrequency Radiation

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Date:	September 18, 1990
Contract No.:	F49620-88-C-0053

Physiological Effects of Whole-Body Exposure

to Millimeter Waves

and

Physiological Effects of Alpha-antagonist Tolazoline

During Whole-Body Exposure to 2.45 GHz Radiofrequency

Radiation

by

Melody R. Welch

ABSTRACT

Ketamine-anaesthetized Sprague-Dawley rats were exposed in E and H orientations to 35-GHz continuous-wave radiofrequency radiation. During experimentation, colonic (T_c), tympanic (T_t), right (T_{sr}) and left subcutaneous (T_{sl}) temperatures, heart rate (HR), arterial blood pressure (MAP), and respiratory rate (RR) were continuously recorded. Under both exposure conditions, there was a 3 minute delay in initiation of T_c change, and a 0.5°C T_c "overshoot" when irradiation was stopped. Irradiation to accomplish a 1°C T_c increase from 38.5°C to 39.5°C was accompanied by subcutaneous temperature increase of ~6°C. These observations indicate that circulatory transfer of heat from the periphery was responsible for internal heating. Two different patterns of cardiovascular response were noted. During the 1°C T_c increase, HR and MAP significantly increased in a linear fashion. However, during an initial period of irradiation performed to establish the baseline T_c, HR increased monotonically while MAP increased to a point and then decreased dramatically; a reaction characteristic of cardiovascular shock with heat stroke. Results showed

no orientation-related difference in sites of energy deposition and cardiovascular responses to irradiation. These findings contrast with the marked orientation-influenced differences noted during lower frequency irradiation.

In another experiment, anaesthetized Sprague-Dawley rats were exposed individually to 2.45-GHz radiofrequency (RFR) radiation. Since each animal exhibits a different starting colonic temperature, an initial RFR exposure was performed to increase colonic temperature to a standard level -- 39.5°C. At this point, the source was turned off and the alpha-adrenoceptor antagonist tolazoline was administered via arterial cannula at a volume of 2.0 mL/kg body weight. After colonic temperature returned to 38.5°C, exposure to RFR was performed until a lethal temperature was attained (the lethal event in hyperthermia due to both RFR and environmental heating is cessation of respiration). Survival times and temperatures at which death occurs were recorded. Colonic, tympanic, subcutaneous, and tail temperatures, EKG, respiratory rate, and arterial blood pressure were continuously monitored. Data collected from this experiment are currently being reduced for statistical analysis.

ACKNOWLEDGEMENTS

I wish to thank the USAF School of Aerospace Medicine for allowing me to use their facility at Brooks Air Force Base, TX, Radiation Sciences Division, and for giving me the opportunity to do research using the most modern equipment. I would especially like to thank my effort focal point, Dr. Robert Burton, for sponsoring me in this endeavor, as well as Dr. Robert Blystone, for bringing this program to my attention in the first place. I particularly appreciate the efforts of Dr. Melvin Frei, who was of the greatest help in the development of the project, in the implementation of it, and in making working there a true learning experience (as well as making it fun).

I. INTRODUCTION:

Research suggests that high levels of RFR may cause morphological and/or functional changes in many biological systems (Erwin, 1981). The increasing military use of RFR makes further studies of possible biological effects of great importance. This knowledge is essential to the protection of operational personnel and the general public, and will contribute to the ongoing evaluation of safety standards. The research done at the Radiation Sciences division of the School of Aerospace Medicine at Brooks Air Force Base concerns the effects of millimeter-wave and microwave radiation on the physiology of whole animals. Recently a series of experiments was begun focusing specifically on the effects of continuous-wave, high-frequency microwave radiation and animal orientation to the radiation source on various physiological parameters, such as heart rate, mean arterial pressure, respiratory rate, and temperatures measured in various areas of the body (Frei, 1989). Because previous work by this laboratory showed significant rise in mean arterial pressure and heart rate upon exposure to 35-GHz microwave radiation, it was decided that the next step would be to determine the effect of alpha-adrenoceptor blocking agents on the changes seen in HR and MAP (Jauchem, 1989). My area of research for the summer involved finishing a project determining the physiological effects of 35-GHz millimeter-wave radiation exposure on anaesthetized rats and beginning a study investigating the effects of the alpha-blocker, tolazoline, on the physiology of rats exposed to 2.45-GHz microwave radiation. Seeing as though I had previous experience in both surgery and computers, and had been working in similar areas of microwave radiation research before the summer, I was able to lend a great deal to the

research project, actually conducting the experiment virtually on my own. Unfortunately, the summer ended before all the data could be analyzed, so a definitive conclusion could not yet be reached.

II. OBJECTIVES:

The objectives of my research effort this summer were basically two-fold:

1. To complete statistical analysis of previous data I collected during a microwave-radiation experiment before the summer began and to prepare a poster and paper discussing these data for presentation at the Bioelectromagnetics Society meeting in June as well as for publication purposes. This was the study investigating the effects of 35 GHz microwave radiation on such physiological parameters such as HR, MAP, respiratory rate, and various measures of temperature in anaesthetized rats.

2. To begin experimentation on he project involving testing the effects of the alpha-adrenoceptor blocking agent, tolazoline, on the changes in temperature, HR, and MAP seen during exposure of rats to 2.45-GHz radiofrequency radiation. Both of these goals were reached during the course of my GSRP, but for lack of time, I was not able to complete the statistical analysis on that experiment.

III.

a. Data for the alpha-adrenoceptor blockade study were collected by computer and by hand. Twenty-three male Sprague-Dawley rats, weighing between 342 and 385 g (mean +/- SEM, 357 +/- 4 g) were used in this study. Prior to irradiation, an aortic cannula (Teflon, 28 G, I.D.) was

installed via the left carotid artery for measurement of arterial blood pressure. Ketamine HCl (Vetalar), 150 mg/kg I.M., was administered as the general anesthetic. Ketamine administration at this dose level has been shown to produce prolonged anesthesia in Sprague-Dawley rats (Smith, 1980 and Frei, 1988). Immediately after surgery, the rat was placed on a Plexiglas holder in the RFR anechoic exposure chamber. The animal was instrumented to continuously monitor and record blood pressure and respiratory rate, as previously described (Frei, 1988). Temperature was monitored at four sites: left subcutaneous (lateral, mid-thoracic, side facing the horn antenna) (T_{sl}); right subcutaneous (lateral, mid-thoracic, side away from RFR source) (T_{sr}); right tympanic (T_t); and colonic (5-6 cm post-anus) (T_c). Individual animals were exposed in E and H orientations (left lateral exposure, long axis parallel to electric and magnetic fields, respectively) to 35-GHz RFR. The procedure for animal irradiation was based on T_c change. Since this study focused on thermoregulatory processes, a consistent change in temperature was considered to be more important than a consistent duration of exposure. In order to provide a uniform temperature baseline, animals received an initial exposure ("warm-up") to increase T_c to 39.0 °C, at which point irradiation was discontinued. When T_c decreased to 38.5°C, irradiation was resumed until T_c increased to 39.5 °C. This procedure was repeated for two 1°cycles. During experimentation, readings of physiological parameters were obtained for analysis at 0.5 °C increments during and after irradiation. A Gould 2600S recorder was used to obtain arterial pressure and respiratory rate (RR) measurements. Mean arterial pressure (MAP) and heart rate (HR) were determined from the pressure curves. To

record temperature changes, Teflon probes placed in the aforementioned areas were attached to a computer to produce continuous temperature readings. Data analysis for the study at 35 GHz was completed and prepared for presentation and publication. Data were analyzed by way of the Microstat program for the IBM computer. Analysis of variance was applied to determine if there were any significant differences between values. Graphs summarizing data were created using the Cricket Graph program for the Macintosh computer.

b. The results found in this study are as follows: During the initial warm-up period, the rats were irradiated until T_C increased to 39.0 °C. Following irradiation, the T_C continued to "overshoot" (i.e., increased by 0.5 °C). As shown in Figure 1, HR increased linearly as T_C increased to the point of cessation of irradiation at 39.0 °C; plateaued during the overshoot; and decreased during recovery to 38.5 °C. However, as seen in Figure 2, MAP increased to a critical point and then decreased dramatically while T_C was still increasing. The downturn in MAP began a T_C = 37.5 °C during E-orientation and at T_C = 38.5 °C during H-orientation exposure. RR did not significantly change during the warm-up phase in either orientation.

The times required for T_C to increase from 38.5 to 39.5 °C during E- and H-orientation exposure, and the times required for T_C to return to 38.5 °C when irradiation was stopped are shown in Table 1. The time to accomplish a 1°C T_C increase was similar during exposures in the two orientations; however, the recovery time was greater following E-orientation irradiation. During exposure in both orientations, there was approximately a 3-minute delay between initiation of irradiation and

onset of T_c change, and approximately a 0.5 °C T_c "overshoot" when exposure ended. The T_{sl}, T_{sr}, and T_t increases that accompanied the 1°C T_c increase are listed in Table 2. The T_{sl} increase was significantly greater (~6X) than the T_c change; the T_{sr} was significantly less; and the T_t change approximated the T_c increase. The HR, MAP, and RR changes that accompanied the 1°C T_c increases are listed in Table 3. As T_c increased from 38.5 to 39.5 °C T_c, HR and MAP significantly increased; no significant differences were seen between the two exposure orientations. In both orientations, RR did not significantly change during the 1°C T_c increase. In all cases, values returned to near baseline levels during the recovery period.

IV.

a. Data for the alpha-adrenoceptor blockade study were collected by computer and by hand. Animals were supplied with an arterial cannula in order to measure and record blood pressure changes during the experiment. Teflon temperature probes were inserted in various areas (in the colon by way of the rectum, in the ear, under the skin on the right and left sides of the animal, and under the skin on the tail of the animal) in order to monitor the temperatures during the entire exposure. The physiological variables heretofore mentioned were recorded at 0.5°C increments throughout the entire exposure for each rat. Animals were exposed to 2.45-Ghz microwave radiation in an anechoic chamber. A warm-up exposure to increase colonic temperature to 39.5°C was performed on each animal to again standardize body temperature. The source was then turned off and the animal was immediately injected with tolazoline 2.0 mL/kg

body weight. After the colonic temperature decreased to 38.5 °C, the source was turned on again until the animal expired. The time for each animal to reach death in this final exposure as well as the T_C at the time of death were recorded in addition to the physiological variables mentioned before.

b. The results of this study cannot be reported at this time. Data are currently being reduced for statistical analysis to prepare them for submission for publication.

VI. RECOMMENDATIONS:

a. The results of such research could be implemented in any review studies dealing with the physiological effects of millimeter wave electromagnetic radiation and for preparing safety guidelines for the use of such radiation around biological organisms. Because of increased military and civilian use of RFR, the knowledge that high levels of RFR can cause morphological and/or functional changes in biological systems makes further studies of possible biological effects of great importance (Erwin, 1981). This knowledge is essential to the protection of operational personnel and the general public, and will contribute to the ingoing evaluation of safety standards.

b. Some suggestions for follow-up research would be to repeat such experiments using any of various types of alpha- or beta-adrenoceptor antagonists of agonists, or repeat then using different frequencies of RFR. This way results can be compared and contrasted between studies, perhaps revealing trends or other interesting information.

c. Seeing as though usage of RFR has increased for both military and civilian purposes, research of this kind is very important because of the lack of it that has been done in the past. Research in the field has only

recently begun (within the last 10 years) (Erwin, 1981) and very little has been done in actual living whole-animal systems. The need for such investigation is obvious if continued use of RFR is going to be safe for all.

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Figure 1: Mean Heart Rate For W-up Phase; E Vs. H Orientations

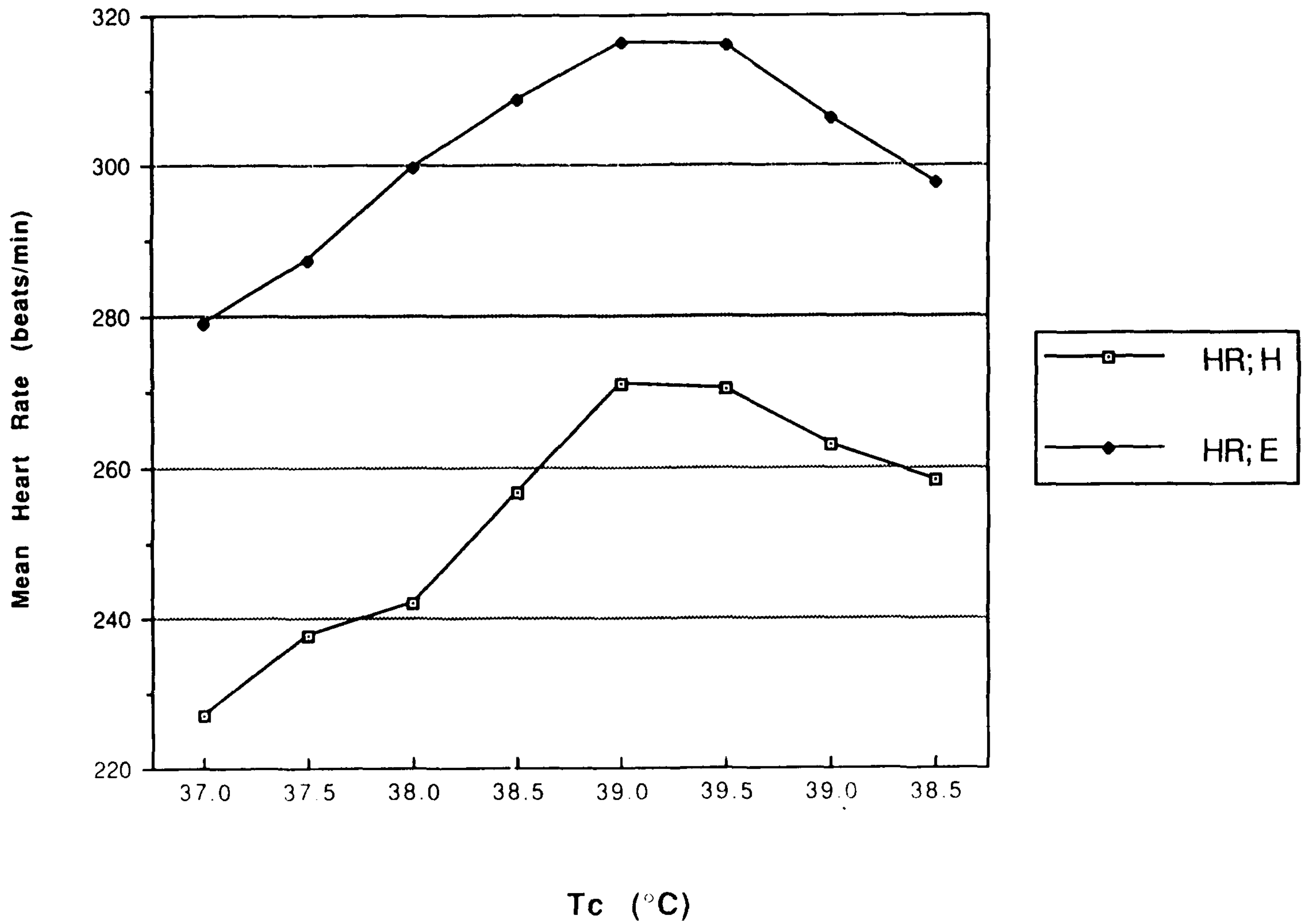

Figure 2: Mean Arterial Pressure For W-up Phase; E Vs. H Orientations

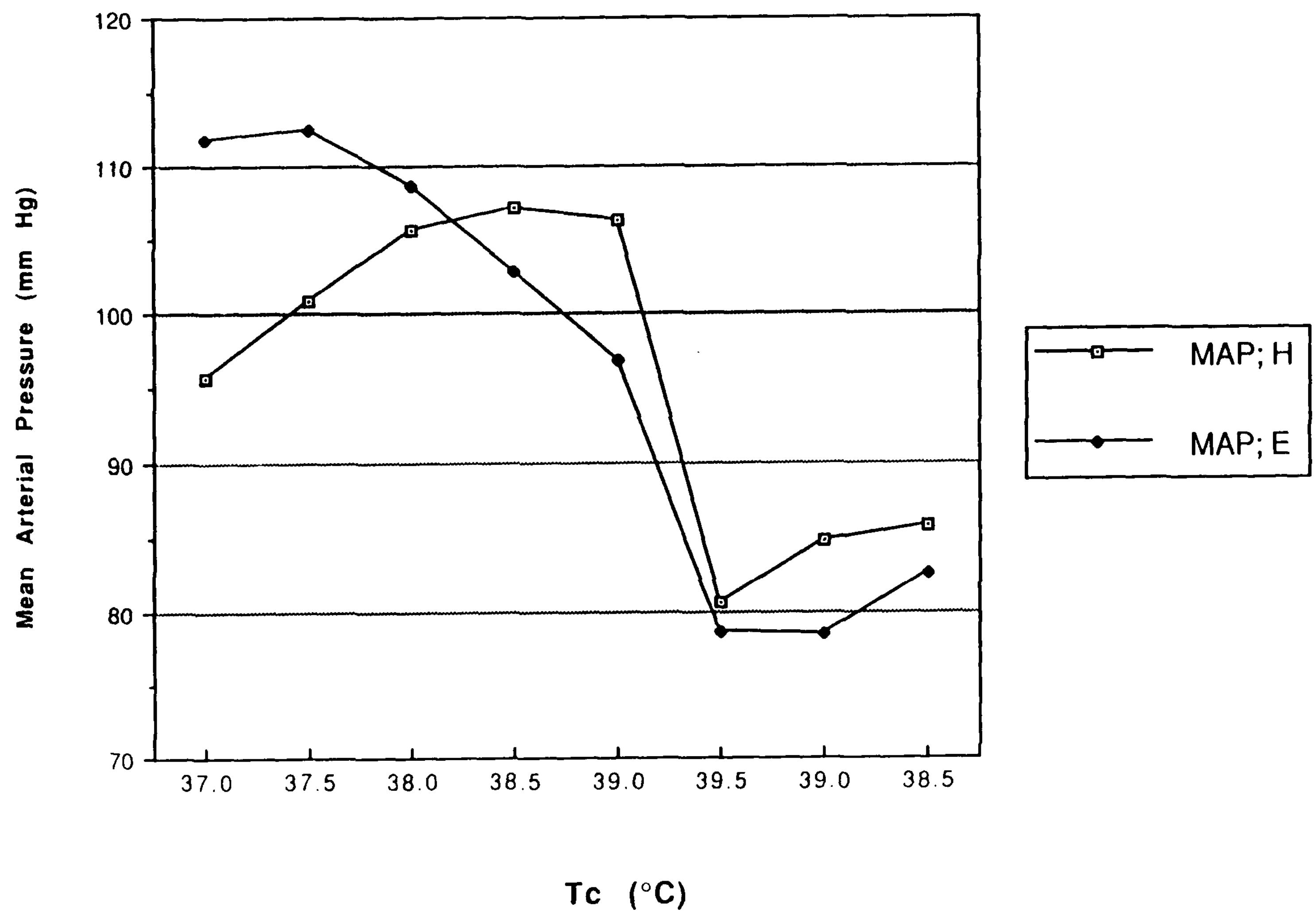

Table 1. Colonic temperature (T_{co}) changes (mean ± SEM) in rats (n=23) exposed in E and H orientations to 35-GHz CW radiofrequency radiation

Exposure Condition	Rise time (min)[a]	Recovery time (min)[b]
E orientation	11.4 ± 0.4	57.4 ± 7.5
H orientation	12.4 ± 0.4	38.1 ± 3.3

[a]Rise time = time to achieve a 1°C T_{co} increase

[b]Recovery time = time to recover to initial temperature after irradiation

Table 2. Local temperature increase (mean ± SEM) that accompanied a 2°C colonic temperature increase during warm-up phase of exposure of rats (n=23) to 35-GHz CW RFR in E and H orientations

Temperature Monitoring Site	Temperature increase (°C)	
	E orientation	H orientation
Left subcutaneous[a]	4.2 ± 0.4	4.3 ± 0.7
Right subcutaneous[b]	1.5 ± 0.1	1.6 ± 0.1
Tympanic	1.9 ± 0.5	1.9 ± 0.3

[a]Side toward RFR source

[b]Side away from RFR source

TABLE III. Cardiovascular and respiratory changes (mean ± SEM) in rats (n=23) exposed to 35-GHz RFR in E and H orientations. Rats were irradiated to change colonic temperature from 38.5 to 39.5°C, after which the temperature was allowed to return to 38.5°C.

Parameter & Orientation	Colonic Temperature (°C)			
	38.5	39.0	39.5	39.0
Heart Rate (Beats/min)				
E	310 ± 9	327 ± 10	340 ± 10*	323 ± 12
H	258 ± 11	287 ± 10	296 ± 8*	269 ± 11
Blood Pressure (mm Hg)				
E	85 ± 3	90 ± 4	90 ± 4*	77 ± 3
H	85 ± 4	95 ± 4	94 ± 4*	79 ± 3
Respiratory Rate (breaths/min)				
E	109 ± 9	115 ± 8	111 ± 7	93 ± 4
H	109 ± 5	109 ± 5	115 ± 8	105 ± 6

*Indicates significant difference ($p < 0.05$) between value at 39.5°C and baseline value at 38.5°C.

1990 USAF-UES SUMMER FACULTY RESEARCH PROGRAM/

GRADUATE STUDENT RESEARCH PROGRAM

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FINAL REPORT

Interrelationships of Tobacco, Caffeine, and Alcohol Use Among Participants of an Air Force-Sponsored Health Promotion Program

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Date:	August 7, 1990
Contract No:	F49620-88-C-0053

Interrelationships of Tobacco, Caffeine, and Alcohol Use Among Participants of an Air Force-Sponsored Health Promotion Program

by

Joan E. Estes

ABSTRACT

Participants of a health promotion program at Wilford Hall USAF Medical Center were surveyed to assess predictors of change in health-related behaviors. Also, the participants were asked about their consumption of caffeine, nicotine, and alcohol so that hypothesized co-occurrence of usage could be investigated. The predictors of change study is on-going. The co-occurrence study provided some support for the proposed interrelationships among the three behaviors. Specifically, a significant correlation was found between number of cups of caffeinated coffee drunk and number of cigarettes smoked, total number of caffeinated beverages drunk and number of cigarettes smoked, number of glasses of beer drunk and number of cigarettes smoked, and number of cups of caffeinated coffee drunk and number of glasses of beer drunk. Sex differences were found in the consumption of all alcohol, beer alone, liquor alone, all caffeinated beverages, and all coffee.

ACKNOWLEDGMENTS

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems must be mentioned for their concern and help to me in all administrative and directional aspects of this program.

My experience was rewarding and enriching because of many different influences. Maj. Wayne Talcott, Maj. John Roe, and Capt. Alan Peterson were helpful in giving structure to this project and in easing my introduction to the military. I would like to thank Lt. Col. Edwin Whitney for allowing me to coordinate this project with his ongoing research and his volunteers for their assistance in data collection. Dr. Janet Dizinno's guidance, support, and encouragement helped to kindle within me a desire to perform research.

I. INTRODUCTION:

In recent years, there has been a tremendous increase in concern about health. This can be seen by the popularity of fitness centers, gyms, and weight-loss programs. Many organizations have realized the benefits of having a healthy workforce: decreased absenteeism, lowered accident rates, and fewer insurance claims; and have developed company wellness programs to promote healthy lifestyles. Little scientific research has been conducted to determine what factors predict success in such programs. Knowledge of such variables may lead to the development of programs which could be adapted to meet the needs of participants who do not have all the characteristics predictive of success in typical health programs. Wellness programs also advocate smoking cessation and moderation in the use of alcohol and caffeine. By studying the interrelationships of these three behaviors, it may be shown that to eliminate or moderate the use of nicotine, alcohol, or caffeine the use of all three must be addressed.

The physicians at Behavioral Health Psychology (BHP) at Wilford Hall Medical Center (WHMC) are interested in looking into the above-mentioned areas in relation to the WHMC Wellness Program. This program is open to all Air Force personnel and their dependents, but is primarily attended by retirees.

I received my bachelor's degree in psychology at Benedictine College, Atchison, Kansas. While there I developed an interest in stress management and employee assistance programs. I presented "Stress in the Workplace: Causes and Effects" at the Great Plains Student Psychology Convention in March 1988. Also, I prepared a report on training recommendations for a newly-developed electronic

data processing system while performing an internship as a Human Factors Engineer at AT&T.

Currently, I am working towards my master's degree in industrial/organizational psychology at St. Mary's University, San Antonio, Texas. I have served as a graduate assistant to the psychology graduate adviser. My main interest is the development of retirement programs within industry. These programs would include such areas as financial planning, health promotion, and counseling to reduce the stresses and anxieties associated with retirement.

II. OBJECTIVES OF THE RESEARCH EFFORT:

My major professor, Dr. Janet Dizinno, and I collaborated on our summer research projects. Our first objective was to explore the vast array of research studies being either conducted or considered by BHP, and then to select one or two to pursue during our ten weeks. In the process of selecting projects we conducted extensive literature searches on the following: anticipatory nausea and vomiting in cancer patients; treatment of headaches with relaxation and cognitive therapy; bulimic behavior and mandatory weight standards; expectancy effects of therapists; health promotion programs and behavior change; and interrelationships of caffeine, alcohol, and nicotine consumption. We shared our findings from the literature searches with appropriate colleagues at BHP, and chose to focus on two projects for the remainder of the summer.

First, we decided to assess a health promotion program being conducted by a WHMC cardiologist, Lt. Col. Edwin Whitney, M.D. We chose to focus on demographic, personality, and behavioral characteristics that might be correlated with changes in health-related behaviors since

results might be applicable to other behavior change efforts such as smoking cessation programs or psychotherapy.

Second, we were fortunate enough to meet Dr. Joseph Matarazzo, a noted behavioral health psychologist, when he visited WHMC to hold Grand Rounds. During one of our meetings with him we learned of his prior work investigating the apparent interrelationships among caffeine, nicotine, and alcohol consumption. One of his studies used subjects with a mean age of 36 years, who participated in a health-promotion program. His other study involved active duty military personnel. No one had looked at the co-occurrence of these behaviors in a retirement-aged population. Thus, we decided to include questions regarding consumption of the three substances when we assessed the WHMC health promotion program because most of those participants are retired from the Air Force, or are spouses of retired Air Force personnel.

III. APPROACHES:

The WHMC health promotion program, called the Wellness Program, is open to all Air Force personnel, retired, active duty, and dependents. Once participants have registered to be in the program, they have a blood sample taken so that cholesterol (HDL, LDL, and triglycerides) and fasting blood sugar can be measured. Then, participants are asked to attend a day-long lecture given by the cardiologist who directs the Wellness Program, Dr. Edwin Whitney. For about seven hours, Dr. Whitney engagingly discusses nutrition and other health-related behaviors, the primary focus being instruction on lowering LDL and triglycerides by changing dietary habits. Just prior to the lecture, participants are weighed. After the lecture, participants are given a laboratory appointment to have blood drawn in approximately

seven weeks, and are given a follow-up appointment to meet with the cardiologist the following week. At this follow-up appointment, participants are weighed and their blood pressure is taken. The cardiologist looks at each participant's cholesterol, glucose, weight, and blood pressure indicators and then makes recommendations. Some participants "graduate" from the program at this time, while others are asked to come back for another follow-up appointment in approximately seven weeks.

Toward our first objective, ascertaining predictors of change by WHMC Wellness participants, we developed a questionnaire to be completed by participants just prior to hearing the day-long lecture by Dr. Whitney. A copy of the survey can be found in the Appendix of this paper. The survey includes questions regarding demographics (name, age, sex, height, marital status, education), stage of change (see Prochaska, DiClemente, Velicer, Ginpil, & Norcross, 1985), self-efficacy, social support, locus of control, and health-related behaviors (sleep, exercise, and the consumption of alcohol, caffeine, and nicotine). All of the psychological factors measured in the survey have at least some empirical support as predictors of some sort of behavior change, yet never have they all been measured at once so that relative predictive value might be determined.

Our second objective was addressed with the last set of questions on the survey (i.e., caffeine, nicotine and alcohol consumption).

IV. RESULTS:

Objective one cannot be completed for several more months because we must wait for participants to attend their follow-up appointments so we can have pre- and post-lecture cholesterol levels to compare. We intend to pursue this

but will be able to develop the project more fully if it is included in the mini-grant (RIP) research funding program offered by UES and USAFOSR. We are in the process of preparing that application.

Objective two was completed during our ten weeks, and the results partially confirmed the previous work by Matarazzo and his colleagues in the United States Army and at Oregon Health Sciences University (Carmody, Brischetto, Matarazzo, O'Donnell, & Connor, 1985; Zavela, Barnett, Smedi, Istvan, & Matarazzo, 1990). The following pairs of variables were significantly correlated with one another: number of cigarettes smoked and amount of caffeinated coffee drunk (r = .22, n =377, p < .0001), number of cigarettes smoked and total number of caffeinated beverages drunk (r = .21, n = 377, p < .0001), number of cigarettes smoked and number of glasses of beer drunk (r = .14, n = 377, p = .007), number of cups of caffeinated coffee drunk and number of glasses of beer drunk (r = .10, n = 381, p = .05).

After additional data are collected, concordance analyses will be performed to look for patterns of behavior among abstainers.

One-way analyses of variance were performed using sex as the independent variable and amounts of the following as separate dependent variables: cigarettes, total alcohol, beer, wine, liquor, total caffeinated beverages, total decaffeinated beverages, tea, and coffee. The following produced significant F-values: sex x total alcohol (F = 30.95, p < .0001), sex x beer (F = 28.64, p < .0001), sex x liquor (F = 8.95, p = .003), sex x total caffeinated beverages (F =3.50, p = .06 - trend), and sex x coffee (F = 5.09, p = .02). In this sample, 55% of the respondents were women. In each significant ANOVA, men consumed more of the substance than women.

When follow-up data are collected on cholesterol, participants will be asked again to complete the questionnaire in a slightly modified form. We will be able then to assess changes in psychological as well as consumatory factors.

V. RECOMMENDATIONS:

a. Regarding the findings on nicotine, alcohol, and caffeine consumption, it is recommended that medical and mental health professionals keep these frequent, legal behaviors in mind when assessing a patient's current status. If they do indeed occur in clusters, this might represent a broader behavioral style, an issue that should be addressed in future research efforts.

With respect to the study that addresses predictors of change in the Wellness Program, the potential value is most exciting. If we can pinpoint predictors of change in such therapeutic situations, then we can try to reach those people who thus far have not responded to change efforts for other behaviors such as stopping the consumption of alcohol, stopping smoking, losing weight, increasing exercise, or following through with psychotherapy.

b. Two bodies of follow-on work are proposed. First, we intend to continue collecting survey data from Wellness Program participants so that changes in physical health (e.g., cholesterol levels) and psychological state (e.g., stage of change, self-efficacy) can be investigated. We intend to conduct discriminant analyses and multiple regressions on the data so we will have a better understanding of what kind of person responds well to a health promotion program.

Second, due to interest generated by the literature searches at the beginning of the summer, I plan to conduct my master's thesis on a comparison of cognitive therapy and relaxation for the treatment of headaches using BHP patients as subjects. I will collaborate with Dr. Wayne Talcott, Director of Biofeedback Training and Research at BHP.

For both of these projects we will apply for a RIP mini-grant from UES and the USAFOSR.

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WELLNESS SURVEY

PLEASE COMPLETE AND RETURN THIS SURVEY BEFORE THE LECTURE BEGINS
THANK YOU

NAME:____________________ AGE:_____ SEX:_____ HEIGHT:_____

DATE:_____________ PHONE #:___________ MARITAL STATUS:_____

YOUR SS#:___________________

NAME AND RELATIONSHIP OF PERSON UNDER WHOSE SS# YOUR MEDICAL RECORDS ARE KEPT:____

SS# OF PERSON NAMED, IF NOT SELF:_______________

IS YOUR SPOUSE ALSO PARTICIPATING IN THE WELLNESS PROGRAM?_______

WHAT IS THE HIGHEST LEVEL OF EDUCATION YOU HAVE COMPLETED?

A. LESS THAN HIGH SCHOOL
B. HIGH SCHOOL DIPLOMA OR GED
C. SOME COLLEGE
D. COLLEGE DEGREE
E. GRADUATE WORK OR DEGREE

Please answer the following questions by circling the number that best represents your agreement with that statement.

1. As far as I'm concerned, I don't have any health problems that need changing.

1----------2----------3----------4----------5

Strong Disagreement — Strong Agreement

2. I think I might be ready for some self-improvement.

1----------2----------3----------4----------5

Strong Disagreement — Strong Agreement

3. I am doing something about the health problems that had been bothering me.

1----------2----------3----------4----------5

Strong Disagreement — Strong Agreement

4. It might be worthwhile to work on my health problem.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

5. I'm not the one with a health problem. It doesn't make sense for me to be here.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

6. It worries me that I might slip back on a health problem I have already changed, so I am here to seek help.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

7. I am finally doing some work on my health problems.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

8. I've been thinking that I might want to change something about myself.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

9. I have been successful in working on my health problem but I'm not sure I can keep up the effort on my own.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

10. At times my health problem is difficult, but I'm working on it.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

11. Being here is pretty much of a waste of time for me because the problem doesn't have to do with me.

1----------2----------3----------4----------5
Strong — Strong

12. I'm hoping this program will help me to better understand myself.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

13. I guess I have faults, but there's nothing that I really need to change.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

14. I am really working hard to change.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

15. I have a health problem and I really think I should work on it.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

16. I'm not following through with what I had already changed as well as I had hoped, and I'm here to prevent a relapse of my health problem.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

17. Even though I'm not always successful in changing, I am at least working on my health problem.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

18. I thought once I had resolved my health problem I would be free of it, but sometimes I still find myself struggling with it.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

19. I wish I had more ideas on how to solve my health problem.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

20. I have started working on my health problems but I would like help.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

21. Maybe this place will be able to help me.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

22. I may need a boost right now to help me maintain the changes I've already made.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

23. I may be part of the problem, but I don't really think I am.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

24. I hope that someone here will have some good advice for me.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

25. Anyone can talk about changing; I'm actually doing something about it.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

26. All this talk about wellness is boring. Why can't people just forget about their health problems?

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

27. I'm here to prevent myself from having a relapse of my health problem.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

28. It is frustrating, but I feel I might be having a recurrence of a health problem I thought I had resolved.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

29. I have worries but so does the next person. Why spend time thinking about them?

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

30. I am actively working on my health problem.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

31. I would rather cope with my faults than try to change them.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

32. After all I had done to try to change my health problem, every now and again it comes back to haunt me.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

33. When things are not going my way, I think it is useless to try to change them.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

34. My stress seems to be unpredictable.

1----------2----------3----------4----------5
Strong Disagreement | Strong Agreement

35. I find ways to accomplish what I want.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

36. am not able to give what I want to people close to me.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

37. I find myself in situations I feel helpless to do anything about.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

38. I run into problems I cannot solve.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

39. I do not think I have control over things in my life.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

40. I like to take on new challenges.

1----------2----------3----------4----------5
Strong Disagreement — Strong Agreement

41. How confident are you that you can change your health?

1----------2----------3----------4----------5
Not at all — Very

Please answer the following questions by circling the letter of the answer that best represents you.

42. How many hours of sleep do you get on a typical night?

a. Less than 7 hours
b. 7-9 hours
c. More than 9 hours

43. Who referred you to the wellness program?

a. Self
b. Spouse/Other relative
c. Doctor
d. Friend

44. For what specific reason did you come to the wellness program? (Select THE best ONE.)

a. To lose weight
b. To lower cholesterol level
c. To improve health habits
d. Sounded interesting
e. Other (Please indicate ______________________)

45. How often do you participate in a vigorous exercise program or engage in physical activities?

a. 3 or more times per week
b. Weekly
c. Seldom
d. Never

46. Do you have a pet?

a. Yes
b. No

47. Do you live alone?

a. Yes
b. No

48. If no, how many people live with you? ________

Please answer the following questions by writing your response on the blank provided.

49. Do you currently smoke cigarettes? ____________

50. If yes, how many cigarettes per day do you smoke? __________

51. Have you ever smoked cigarettes in the past? ____________

52. How much caffeinated and decaffeinated coffee, tea, and/or cola do you drink per day?

# of cups of regular, caffeinated coffee per day ________
# of cups of decaffeinated coffee per day ________
# of cups of regular, caffeinated tea per day ________
# of cups of decaffeinated tea per day ________
# of bottles of caffeinated cola per day ________
# of bottles of decaffeinated cola per day ________

53. How many alcoholic drinks do you drink per month?

# of 12 oz. beers per month ________
# of 4 oz. glasses of wine per month ________
# of drinks containing 1-2 oz. of hard liquor per month _____

THANK YOU FOR ANSWERING THESE QUESTIONS FOR US.
PLEASE RETURN YOUR COMPLETED SURVEY TO THE SURVEY TABLE.

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FINAL REPORT

The Effect of Race on Birthweight and Outcome in Premature Infants

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Date: 20 Aug 90

Contract Number: F49620-85-C-0013

Stacey Johnson

ABSTRACT

Several authors have suggested that "small black babies achieve better survival rates than small white babies".[1,2] This contention is based on data produced from large population studies that do not address other important factors effecting neonatal mortality rates (amount of prenatal care, socioeconomic status, degree of prematurity). The purpose of this study was to query a large, military neonatal database to determine if small black babies did better than small white babies in a population of patients with free access to prenatal care (military system). We reviewed and checked data on 596 infants admitted to the Wilford Hall USAF Medical Center (WHMC) neonatal database. To avoid neonatal referrals from biasing our results, we studied only infants who were born at WHMC (n = 367). Of the 367 inborn infants, 213 were white, 71 were black and 83 were other (eg Hispanic, Asian, Indian). We limited our analysis to white and black infants. We compared average birthweight, survival, incidence of bronchopulmonary dysplasia, and incidence of intracranial hemorrhage between premature black and white infants in four gestational age groups.

ACKNOWLEDGMENTS

We would like to thank the Air Force Systems Command, the Air Force Office of Scientific Research and Wilford Hall USAF Medical Center for there support of this type of research. We would also like to thank John H. Cissik, Colonel USAF, for his supervision during the project, Sonya M. Shuler for her help in manuscript preparation, and Richard F. Stribley, Lt. Colonel USAF, for his computer assistance.

The results are summarized in the table below

	<=25		26-28		29-31		31-34	
	Black	White	Black	White	Black	White	Black	White
Incidence CLD	25%	50%	30%	41%	6%	12%	3%	4%
Incidence IVH	86%	57%	44%	57%	15%	43%	4%	11%
Survival	29%	24%	64%	65%	94%	90%	100%	96%

There was no difference in outcome between black and white infants in any of the outcomes measured. Gestational age at birth was the most important prognostic factor. More immature were smaller at birth and had significantly worse outcome in all measures of morbidity and mortality. These data suggest that the difference in outcome previously noted may be related to other demographic difference rather than racial differences.

I. INTRODUCTION

Several studies document differences in low birthweight (LBW) rate. Neonatal morbidity and mortality between blacks and whites. Some authors attribute these differences to socioeconomic factors, others suggest race alone impacts on the measure of perinatal outcome.

Prior to my visit to Wilford Hall USAF Medical Center (WHMC), a professor at my medical school (Meharry Medical College) suggested an independent research project. That project was to document the birthweights of infants of mothers who were placed in certain categories (i.e. smokers, nonsmokers, drinkers, drug users, drug abusers, etc.). When I applied for the Graduate Summer Research Program, Dr. Clark, a physician at WHMC saw that we shared a mutual interest in LBW infants. Dr. Clark believed we could work together to determine if the reported differences in outcome between black and white LBW infants were present in a military population.

II. OBJECTIVES OF THE RESEARCH EFFORT

Our purpose was to develop and complete a research project evaluating risk factors affecting perinatal morbidity and mortality in LBW infants born at a military regional medical center. My specific aims were as follows:

1. Learn research methods used to acquire background data to support a research project.
    a. Use of computerized library resources search techniques to establish a bibliography of sources. (eg CDROM, mini-medline)
    b. Review articles to develop background information.
    c. Focus in on core articles.
2. To check and complete data entry into neonatal database.
3. To statistically analyze the effect of race and birthweight on neonatal morbidity (intraventricular hemorrhage and bronchopulmonary dysplasia) and mortality in premature infants born at WHMC.
4. Complete final report for UES.

III. BACKGROUND DATA

We studied the risk factors affecting perinatal morbidity and mortality. Low birthweight (LBW) contributes significantly to neonatal morbidity and mortality. Among LBW infants, a number of factors contribute to poor outcome. These factors include race, gender, socioeconomic status, access to prenatal care, maternal age, gestational age, birthweight, prenatal stress, drug use or abuse and marital status. Recent articles suggest that the most important factors are race, socioeconomic status and maternal age.

The military health care system offers a unique population for study. All military personnel and there dependents have free access to prenatal care. We anticipated that free access to care might reduce the impact of race and socioeconomic status on outcome in LBW infants. The purpose of this study was to determine if this conjecture was true.

The Wilford Hall USAF Medical Center (WHMC) maintains a large database on all premature infants born at WHMC (started in 1986). This database includes data on perinatal history, neonatal history and outcome. A summary table is provided:

Maternal Factors	Neonatal Factors	Outcome
Age	Fetal Distress	Chronic Lung Disease
Prenatal Care	Apgar Score	IVH
Infection	Est. Gest. Age	Death
Smoking	Birthweight	
Blood Type	Degree of Lung Disease	
Race	Need for Assisted Ventilation	
	Race	

After updating and checking the database, we analyzed the data in order to answer our proposed question.

IV. METHODS (Objectives 3 & 4)

After gathering our background information we entered data essential to our research topic. Data concerning birthweight was checked against obsterical records. Race and survival data was checked against the hospital computerized record. Records of head ultrasounds were reviewed to verify that the grade of intracranial hemorrhage was properly recorded in the database. And arterial blood

gases were reviewed to determine if the infant had bronchopulmonary dysplasia. To determine if race effected outcome we subdivided the data according to estimated gestational age (EGA). This was done to block EGA as a confounding variable.

V. RESULTS

596 records of premature infants (<34 wks gestation) were reviewed and checked. To avoid referral bias caused by patients transferred to WHMC for special therapies only those infants born at WHMC were included in the study (N=367). Of the 367 inborn patients, 213 (58%) white and 71 (19%) were black. Birthweight, bronchopulmonary dysplasia (BPD) at 36 weeks postconception age (PCA), intraventricular hemorrhage (IVH), and survival were studied.

The following graphs summarize the results of our research. There was no difference in mean birthweight or survival between black and white infants at any given gestational age (see figures 1 and 2).

The the incidence of bronchopulmonary dysplasia (BPD) (figure 3A) and the incidence of severe BPD (figure 3B) decreased with increasing gestational age. While there was

no significant difference between the two races in the incidence of BPD, the incidence was higher in white infants than in black infants at each gestational age.

The incidence of intraventricular hemorrhage IVH (figure 4) and the incidence of severe IVH decreased with increasing gestational age. Black infants born less than 25 weeks gestation had a higher overall incidence of IVH than white infants at the same gestational age. There were no other race related differences in the incidence of IVH.

VI. DISCUSSION

Several articles demonstrate that the overall mortality rate for black infants is greater than that for white infants. The ratio of differences in neonatal mortality quoted in these articles is 2:1.[1,2,3] In contrast, the mortality rate for black LBW infants (<2500 grams) is lower than it is for white LBW infants.[1,2,3] The mortality rate for black infants does not exceed that of white infants until the infant birthweight is above 2500g. Binkin and Wilcox suggested the higher black infant mortality rate was explained by the higher incidence of LBW infants in the black population.[1,2,3] The lower mortality rate of LBW black neonates was attributed to the fact that black

neonates appear to have more mature lungs at the same gestational age.[3] Unfortunatley, none of these studies has addressed access to care as a potential confounding issue.

Maternal age is also an important risk factor. The risk of having a LBW infant at term is lowest in teen teenagers and increases with advancing age.[4] Statistics suggest that the incidence is higher in teenagers.[4,5] This may be due to the fact that teenage pregnancies are associated with a number of confounding maternal factors.[4,5] A higher proportion of these teenagers are black, single, have less education, higher proportion of primigravidas and usually have poorer prenatal care status.[4,5] Older age groups are composed of more mothers who are white, who have gone to college, are married, have had at least one child and tend to have better prenatal care status. All of which (except age) points to a decreasing risk of having a LBW infant. If all of these confounding variables are considered, maternal age does not appear to be an independent risk factor for prognosticating the likelihood of premature labor on delivery.

Low socioeconomic status is also reported to be an important risk factor in predicting LBW and neonatal mortality rates. As the mean family income decreases, there is an increase in the number of LBW infants born in both

races.[6,7] Even when the socioeconomic status is the same, there is still a higher incidence of LBW in black neonates.[7] Socioeconomic disadvantage does not directly cause LBW. Instead it introduced a variety of "biologically active" limitations, stresses and maladaptive coping strategies. For example low income limites access to adequate medical care, restricts nutrition during pregnancy, and is associated with teenage pregnancy, smoking and drug use. All of these factors exert a direct biological effect on birthweight.

The Air Force military population offers a unique population of patients. Economic status is readily determinable and graded by the military rank of the sponsor of the dependent seeking medical care. Prenatal care is provided free of charge and hospitalization results in only nominal charges to the family ($8.00 per day). As we anticipated, this free access to care appears to reduce previously reported racial difference in outcome and average birthweight in premature infants. In our study, gestational age at birth was a much more important factor in determining neonatal outcome and birthweight than race. While these results suggest that free access to prenatal care may have favorable impact on racial difference in neonatal outcome, further analysis is required.

VII. RECOMMENDATION

1. We were unable to complete our multivariate analysis of the database within the time allotted for this research elective. Dr. Clark, Dr. Yoder and Dr. Walsh have an ongoing commitment to further analysis of other factor's effecting neonatal outcome in this unique population of patients. Factors that will be checked this year include maternal age and sponsors rank.

2. While there were no racial specific differences found in outcome, we have not evaluated the effect of race on the LBW rate or overall neonatal mortality rate. Data from a study presented at the Southern Society of Pediatric Research suggest that the military milks mimics the American population as a whole with regards to these two outcome variables. Military black mothers have a higher likelihood of delivering a LBW infant and neonatal mortality rates among black infants are twice that seen in black infants. We are investigating this observation at WHMC. We hope to determine if these differences are present in our own patients. These observations are important to the development of comprehensive health care plan. If free access to care does not reduce the incidence of LBW or neonatal mortality, then other strategies must be adapted to improve these measures of maternal-child health care.

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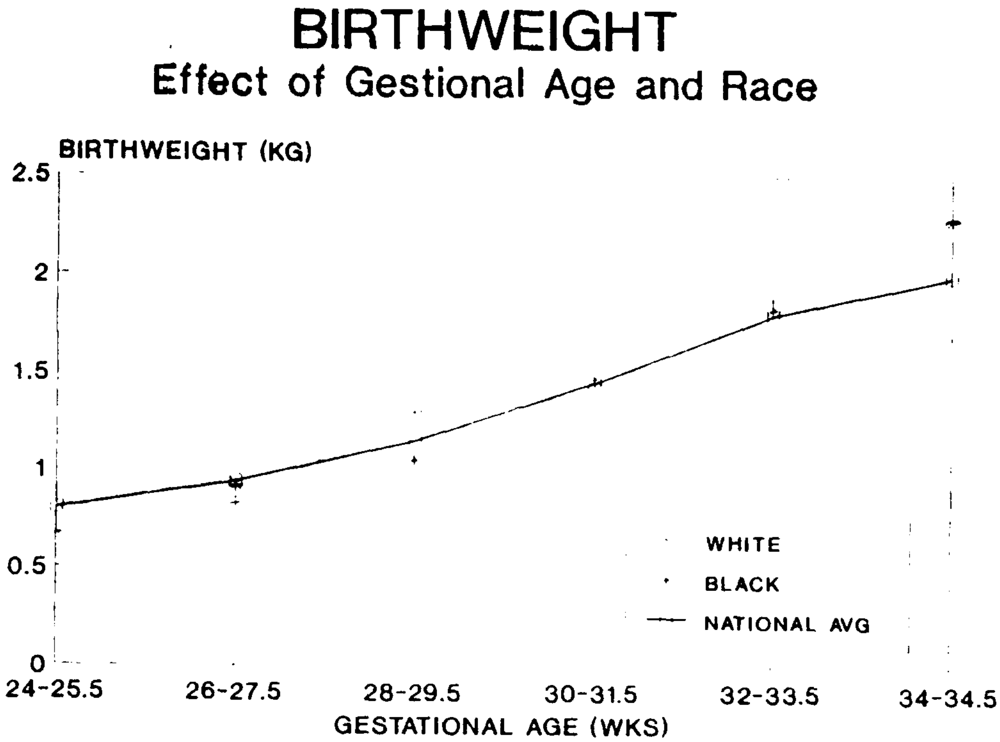

Figure 1

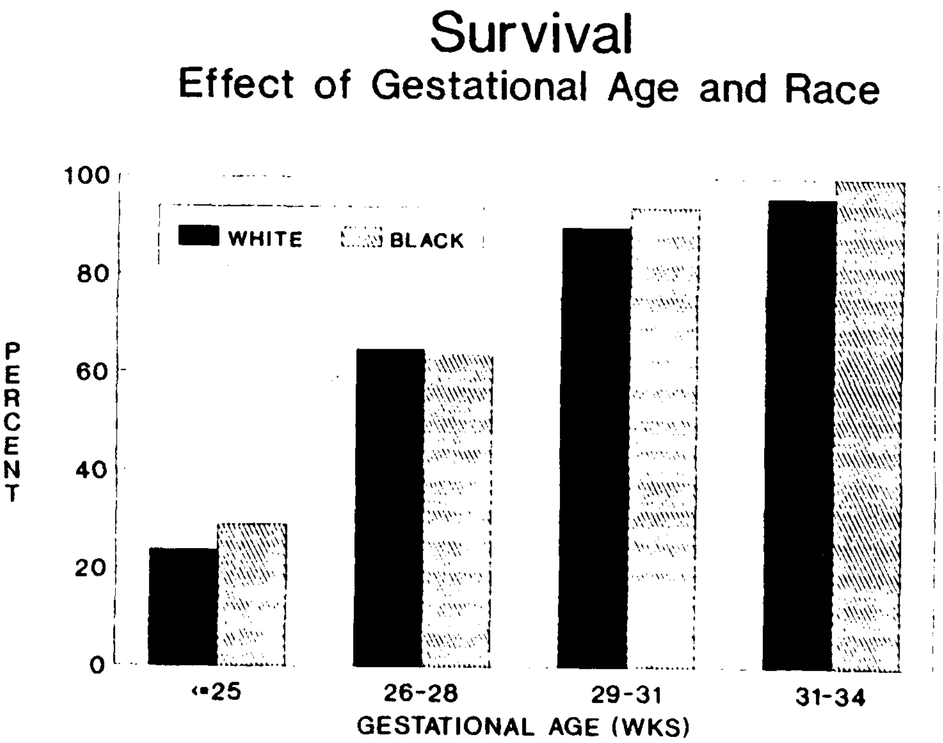

Figure 2

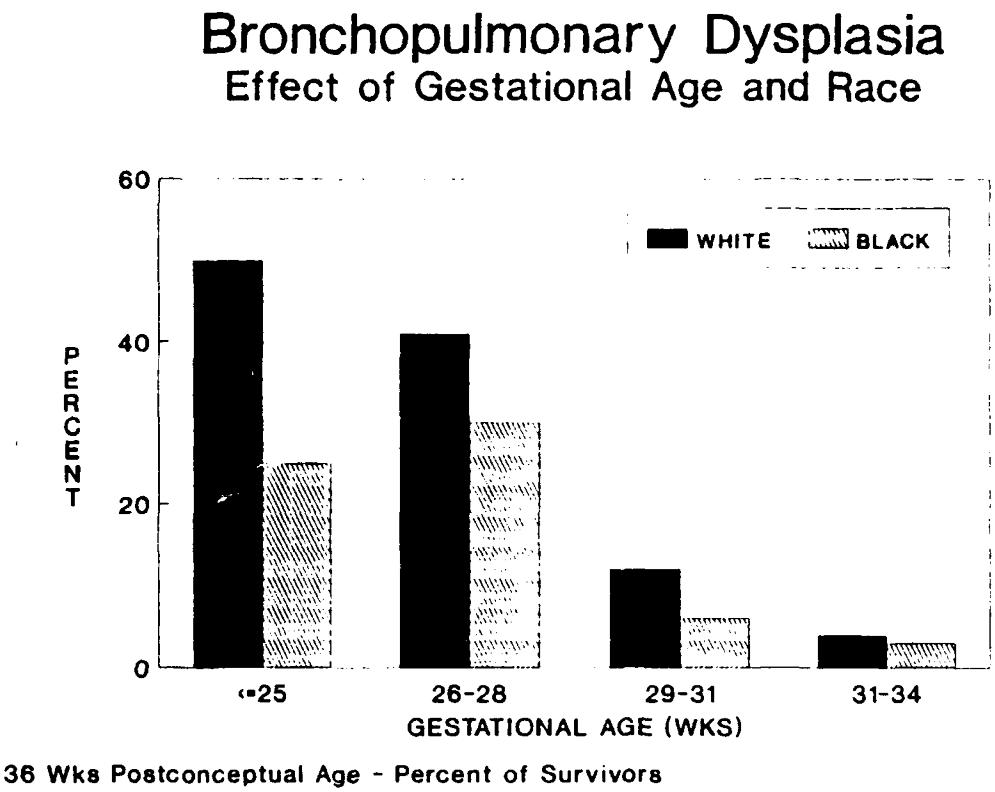

Figure 3A

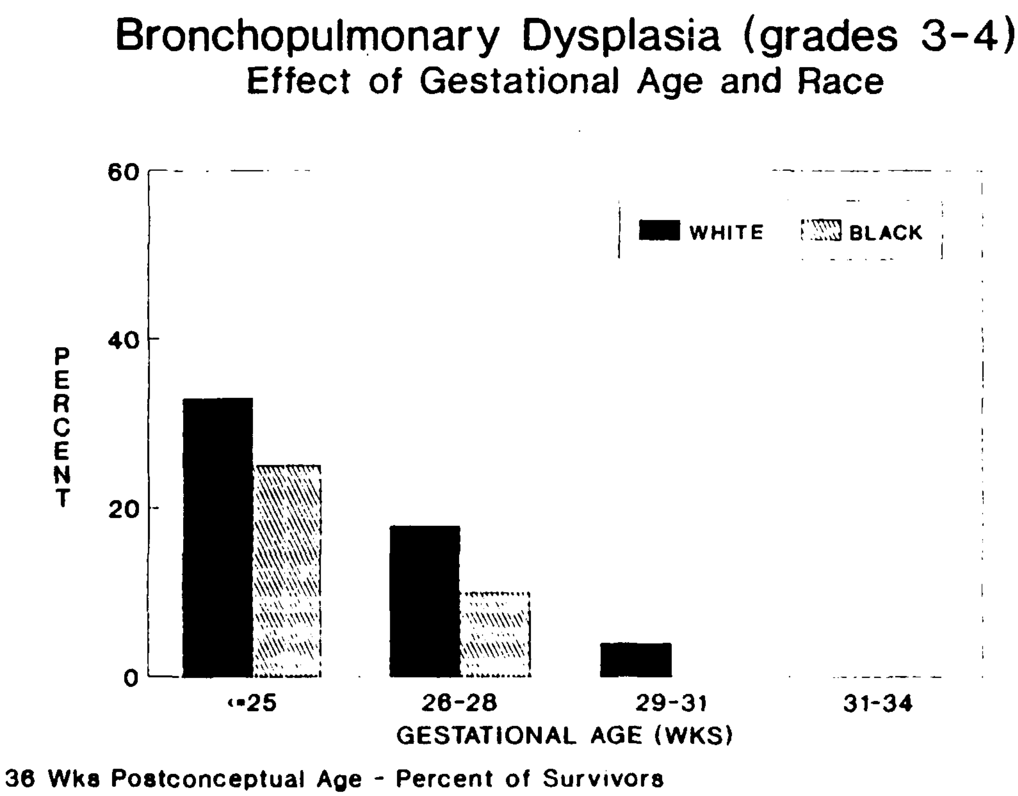

Figure 3B

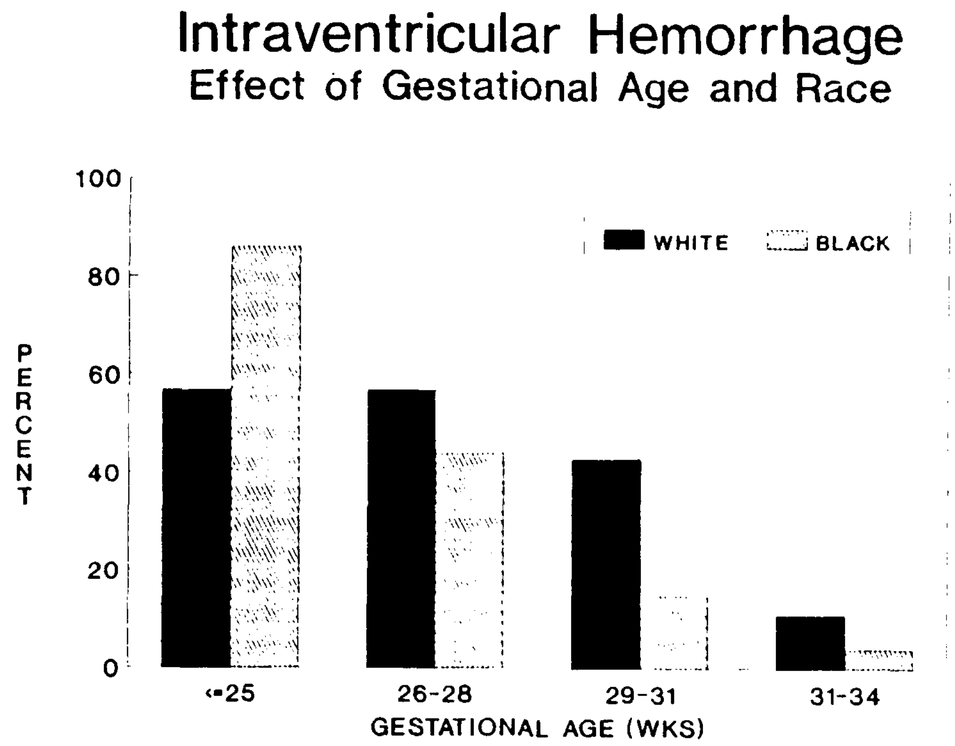
Intraventricular Hemorrhage
Effect of Gestational Age and Race
WHITE
BLACK
PERCENT
100
80
60
40
20
0
<=25
26-28
29-31
31-34
GESTATIONAL AGE (WKS)

Figure 4

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FINAL REPORT

Detection of the Interaction Between Stress and Malingering Among Basic Trainees using the MMPI-2

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Date:	August 7, 1990
Contract No:	F49620-88-C-0053

Detection of the Interaction between Stress and Malingering Among Basic Trainees Using the MMPI-2

by

Susan R. Jones

ABSTRACT

Two groups of basic trainees, those being returned to duty and those being discharged, were given the MMPI-2 twice, once upon intake and again after support group intervention. The interaction between malingering and stress and what occurs when the motivation to malinger is removed was examined. Significant differences were obtained on scale Si (p = .051) when post-group intervention males returning to duty were compared to post-group intervention males being discharged. A comparison of pre- and post-group intervention for males being discharged revealed significant differences for scale F (p = .047) and scale Pa (p = .051). Results suggest that basic trainees' exaggeration of symptoms declines after group intervention or when the trainees are removed from stressful situations. There were no actual occurrences of malingering.

ACKNOWLEDGMENTS

I wish to thank the Air Force Systems Command and the Air Force Office of Scientific Research for sponsorship of this research. Universal Energy Systems must be mentioned for their concern and help to me in all administrative and directional aspects of this program.

My experience in the program has been very meaningful and a rewarding learning opportunity because of the direction and support of many different individuals. Dr. Edna Fiedler provided me with support, direction, and invaluable research opportunities. Dr. Wayne Talcott's guidance and encouragement were very helpful. The help and concern of all the personnel at SAS provided me with many rewarding experiences and an enjoyable work atmosphere. Mr. Rich Deary, Mr.Tom Swanson, and Sgt. Prinz were especially encouraging and invaluable during difficult phases of the research project. The cooperation and concern of the technicians at BAS helped make my research project possible and my experience in the program extremely enjoyable. The encouragement and guidance that Dr. Janet DiZinno and Ms. Joan Estes provided were truly invaluable. Their enthusiasm and support were greatly appreciated.

I. INTRODUCTION:

Basic military training (BMT) is a period of extreme stress. Many trainees desire a discharge from the military once they enter basic training. Therefore, it is possible that they will be highly motivated to malinger in order to receive a discharge. For this particular study, malingering is defined as the intentional faking or exaggeration of physical or psychological symptoms, usually motivated by external incentives (APA, 1987). It is very important for the military to be able to identify which trainees are truly malingering so that necessary recommendations can be made. For example, appropriate support groups help many trainees successfully cope with BMT. In addition, actual cases of malingering need to be accurately identified since this is considered a serious offense to the military and could result in possible incarceration.

Behavioral Analysis Services (BAS) is an outpatient evaluation clinic particularly concerned with malingering since their recommendations are a deciding factor in whether trainees are returned to duty (RTD) or discharged. BAS provides psychological testing and support groups for active duty personnel. Basic trainees receiving services are interviewed to determine whether they should RTD or be separated from the military. Clinical providers use psychological test results, interviews, and diagnoses to aid in their recommendations. The MMPI-2 is a widely respected personality instrument that is often used to detect malingering and aid in the determination of diagnoses for basic trainees (Hawk & Cornell, 1989; Rice, Arnold, & Tate, 1983; Schretlen, 1988; Walters, 1988; Wasyliw, Grossman, Haywood, & Cavanaugh, Jr., 1988).

BAS personnel are specifically concerned with how stress interacts with motivation to malinger on the MMPI-2.

There is a very limited amount of research in this area and the majority of studies have examined the role stress plays in malingering among prison inmates (e.g., Walters, 1988), college students (e.g., Schretlen, 1988), and individuals with post-traumatic stress disorder (e.g., Foy, Sipprelle, Rueger, and Carroll, 1984). However, very few studies have actually examined what happens to the motivation to malinger when stressors are removed. This field study provided the opportunity to detect the interaction between stress and malingering during stress and in post-stress situations while comparing two groups.

I am currently a graduate student at St. Mary's University, San Antonio, Texas, and have spent the last year in the Clinical Psychology master's program. This particular program emphasizes psychological testing and assessment. I developed an interest in clinical psychology while obtaining my bachelor's degree in psychology. My undergraduate college emphasized the importance of research and as a senior I developed and ran my own study in the area of self-esteem. Since that time, I have taken classes at St. Mary's that stimulated my interest in research. I particularly desired a research experience in a clinical setting and the study involving the MMPI-2 allowed me this opportunity.

III. OBJECTIVES OF THE RESEARCH EFFORT:

Intially my assignment in the Summer Graduate Research Program was to work on two studies. The first objective was to collect data on basic trainees who were seen at BAS due to unusual responses on the Air Force Medical Evaluation Test (AFMET), a test given to determine who will successfully complete basic training. The AFMET basic trainees were to be compared to basic trainees who were

referred by their training instructor or squadron leader due to difficulties coping with BMT. Data entry was initiated and continued throughout my work period. However, data analyses were not pursued at this time because the study required more manpower hours than originally was thought necessary. Therefore, the rest of the paper will address the second objective.

The second objective during my assignment was to compare basic trainees' MMPI-2 profiles obtained during stress with trainees' MMPI-2 profiles obtained post-stress. Although prior work has demonstrated that motivated subjects will malinger (e.g., Schretlen, 1988), this study is the first to include a repeated measures component to examine what occurs with the validity scales of the MMPI-2 when the motivation to malinger is removed.

It was proposed that at intake at BAS individuals being discharged from the military and recommended to the Personnel Processing Squadron (PPS) would have more pathological scores on the MMPI-2 than individuals RTD and referred to Airman's Support Group (ASG). More specifically, PPS raw scores on the MMPI-2 were predicted to be higher, on the the average, across clinical scales. In addition, PPS trainees were predicted to display more malingering (scales F-K, with a higher F and a lower K) on the MMPI-2 and more serious diagnoses than ASG individuals. Furthermore, the MMPI-2 scores obtained after the trainees had entered a therapy group (the intervention) were to be compared. It was predicted that PPS scores would have a significantly greater change than ASG scores, which would result in a smaller difference between the two groups at post-intervention. Also, PPS scores after group intervention were predicted to move toward normality on all of the validity and clinical scales. Therefore, there would be a reduction in "faking bad", since F would decrease and K

would increase. However, ASG scores were predicted to change very little since these individuals were still under stress and had returned to BMT. Additional comparisons were to be made to determine if there might be an interaction between type of classification (PPS or ASG) and sex.

II.

a. Thirty-six basic trainees (21 males, 15 females) ranging in age from 17 to 23 (M = 20; SD = 1.3) participated in the study. All of the subjects who participated in the study had requested or been referred for services at BAS due to difficulties experienced in basic military training. Basic Trainees receiving services are first interviewed to determine whether they should return to duty or be separated from the military, and then the appropriate support group is recommended. Subjects were divided into two groups: 17 subjects attended ASG, which is a remotivation group for basic trainees RTD who are experiencing difficulties adjusting to basic military training. The ASG is a one-hour, twice weekly process, in which trainees learn coping skills for basic training under the direction of a credentialled mental health provider. There are, on the average, 18 trainees in each session and trainees typically attend three sessions. The second group of subjects (n = 19) were in the PPS group, which is a support group for basic trainees being discharged from the military. Format and structure is the same as for the ASG, with an emphasis on adjusting to separation from the military, future goals and plans, and current emotional difficulties. There are, on the average, 15 individuals in each session and, typically, two sessions are attended.

All subjects were administered the MMPI-2 twice. The first administration of the MMPI-2 was part of a routine assessment performed at BAS prior to recommendation to either group. The psychologist evaluating the recruit then recommended the subject for either ASG and RTD or to the PPS group and discharge from the Air Force. After the subject attended at least two group sessions, he or she could voluntarily participate in a second administration of the MMPI-2. Clinical scales and the validity scales L, K, and F were scored. T and F tests were computed to compare MMPI-2 raw score means and variances of the ASG to the PPS group, as well as pre- and post-group scores. The MMPI-2 profiles for each group of subjects were compiled using K corrections. Then the composite profiles for ASG and PPS groups were compared. In addition, a comparison of pre- and post-group MMPI-2 composite profiles was made for each group.

b. There were no significant differences between the PPS and ASG females' MMPI-2 scores prior to group intervention, although PPS females did have higher elevations on scales L, Hs, D, Hy, Pa, and Pt (see Figure 1). These results are interpreted as indicating that both groups were experiencing similar amounts of stress before group intervention.

PPS females' F scores are in the questionable validity range (_T_ = 80), but the F-K of 0 and K T-score of 42 are in the modal range. For ASG females, both of the validity indicators of high F and low K T-scores are beyond the valid range. These validity scores are interpreted as indicating an exaggeration of symptoms and a plea for help (Hathaway & McKinley, 1989). An interpretation of actual malingering would be difficult to make in light of the small sample size, the F-K ratio and, for the PPS group, the modal range

of the K scores. In addition, there were no significant differences between the PPS and ASG females' MMPI-2 scores after group intervention, although PPS females maintained higher scores on Hs, D, Hy, Pt, and Si (see Figure 2). Scores on all of the scales (except Ma for ASG) moved closer to the modal range in comparison to pre-intervention scores.

A comparison of the validity indicators shows that the ASG scores remain the same as prior to group intervention, but that the PPS scores move into the modal range. Even though there is less exaggeration of symptoms for the PPS post-group females, they still experience more difficulty in dealing with stress than the ASG females. ASG females continued to show questionable validity, but their clinical scales dropped, suggesting that group intervention was helpful in dealing with stress.

A comparison of pre- and post-group intervention scores for the PPS females shows that all scale scores except L and Si, moved in the direction of the modal range after two days, and not more than 7-10 days, of group intervention (see Figure 3). There was an average change of 4.5 in T-scores. All of the validity indicators moved to within acceptable limits. None of these trends were statistically significant, however.

The change in the validity indicators and the decrease in the clinical scales are interpreted as reflecting the decrease in personal distress after being informed they would be removed from the stressful situation. The elevated scores of the post-intervention PPS subjects probably reflect the fact that these women are experiencing ongoing psychopathology or serious adjustment disorders that were only amplified by their current stress. A comparison of pre- and post-ASG intervention for females indicated that there were no significant differences in scale scores, even though there was a drop in all clinical scales, except Ma

(see Figure 4). The validity scales' scores remained the same as at pre-group intervention. The excessive validity indicators are seen as continued pleas for help. However, the decrease in clinical scales' scores is interpreted as indicating that group intervention is helping the ASG females better cope with BMT stress. In other words, ASG females are doing better with their ongoing stress, even though they do not like it.

There were no significant differences between the PPS adn ASG males' MMPI-2 scores prior to group intervention, although PPS males did have higher elevations on scales F, Hs, D, Pa, Pt, Sc, and Si (see Figure 5). These results indicate that both groups were experiencing similar amounts of stress before group intervention.

PPS males' F, scores are in the questionable validity range ($\underline{T}$ = 85), but the F-K of 5 and K T-score of 42 are in the modal range. These validity scores are interpreted as indicating an exaggeration of symptoms and a "plea for help" (Hathaway & McKinley, 1989). An interpretation of malingering would be difficult to make in light of the small sample size, the F-K ratio, and the modal range of the K score. For the ASG males, all of the validity indicators are within the modal range. This indicates that the ASG males are not exaggerating their symptoms and there are no signs of malingering.

There were no significant differences between the PPS and ASG males' MMPI-2 scores after group intervention, except for scale Si ($\underline{p}$ = .051). However, PPS males maintained higher scores than ASG males on D, Pd, Pa, Pt, Sc, and Si (see Figure 6). All of the scale scores (except Ma) moved closer to the modal range in comparison to pre-intervention scores.

A comparison of the validity indicators shows that the ASG scores remained within the modal range. PPS males' F

score moved into the modal range while the other validity indicators remained the same as prior to group intervention.

Therefore, even though there is less exaggeration of symptoms for the PPS post-group males, they still experience more difficulty in dealing with stress than the ASG males. In addition, PPS males are significantly more introverted, shy, and depressed than ASG males, as indicated by the Si T-score of 66. The clinical scale scores dropped for ASG males suggesting that group intervention was helpful in dealing with stress.

A comparison of pre- and post-group intervention for the PPS males shows that all scale scores except, L, K, MF, and Ma moved in the direction of the modal range after two to ten days of group intervention. There was an average change of 8.3 in T-scores. The validity indicator F moved to within acceptable limits; whereas, L and K remained the same. There was a significant decrease in scale F (p = .047) and in scale Pa (p = .051). The remaining trends were not significant.

The change in scale F and decrease in clinical scales are interpreted as reflecting the decrease in personal distress after the males were informed that they would be removed from the stressful situation. The increase in scale Ma probably indicates an increase in energy among the PPS males. The elevated scores of the post-intervention PPS participants probably reflects the fact that these men are experiencing ongoing psychopathology or serious adjustment disorders that were only amplified by their current stress.

Furthermore, a comparison of pre- and post-ASG intervention for males shows a decrease in all clinical scale scores (except Ma) in the direction of the modal range. The validity indicators remained within the modal range. There were no significant differences in the trends. However, the decline in clinical scale scores indicates that

group intervention is helping the ASG males better cope with BMT stress.

V. RECOMMENDATIONS:

a. The results obtained from the study will allow the mental health providers at BAS to have more confidence in their diagnoses and recommendations for basic trainees. Furthermore, the results substantiate the use of the MMPI-2 as a valid assessment of malingering. Therefore, the MMPI-2 profiles can be utilized more often in potential cases of malingering. However, the results also indicate that diagnoses of malingering should be made with caution since basic trainees tend to exaggerate because of their experiences in BMT. PPS individuals appear even more susceptible to having problems coping with BMT. This information will be useful when recommendations are made for individuals to be RTD or discharged, since profiles are now available as references that suggest certain trends in scale scores exist for individuals likely not to cope well with the stress of BMT.

Finally, the study provided an indirect assessment of the support groups at BAS. The results suggest that the support groups are helpful for the trainees and aid in the reduction of stress and probably help improve the trainees' coping skills.

b. In future research at BAS, MMPI-2 profiles obtained for each of the groups will be compared to MMPI-2 norms and the male MMPI-2 profiles will also be compared to military norms. This information will be useful in determining if basic trainees need different norms for scoring purposes.

Furthermore, additional subjects' MMPI-2 scale scores will be added to the pre-ASG and pre-PPS groups for both

males and females. This will increase the sample size and allow for the possibility of results that reach significance. If these results do reach significance, then a larger study will possibly be done to replicate the original study.

c. Larger sample sizes would have been more useful and would have provided more information. The results do indicate clear trends, but significant results were not obtained possibly due to the small sample sizes. Because we relied on volunteers, willing participants were difficult to obtain to take the second MMPI-2. It also may have been helpful to have given the pre- and post-intervention MMPI-2's further apart, since test-retest reliabilities were possibly a confounding factor due to the short time between tests and retests.

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Figures May Be Obtained

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